

The Future of Linux*

Table of Contents:	2 A Future of Growth
	2 Market Analysis
	3 Desktop to Data Center Linux
	5 The Future of Linux on the Desktop
	6 The Future of Linux on the Server
	10 The Future of Linux in the Data Center
	14 Excursion: Linux and Web 2.0
	15 Looking Ahead



A Future of Growth

Novell has the ability to impact the direction of Linux, and we obviously have our own thoughts about where the future of Linux lies. This white paper outlines our vision for the future of Linux—from the desktop to the data center.

-
- 1 IDC: "Worldwide Operating Systems and Subsystems 2007–2011 Forecast," Doc #206193, April 2007
 - 2 IDC: "Worldwide and Regional Server 2007–2011 Forecast," Doc #206466, April 2007
 - 3 IBM OpenSource and LinuxLine Survey, Conducted by Unisphere Research for IBM, October 2006 and Gartner Inc.: *Why the Client OS Matters Well Beyond 2011* by Michael A. Silver and Mark Driver, Aug. 28, 2006

Linux* is experiencing unprecedented growth in the enterprise, not only on servers and in data centers, but also on corporate desktops. Today, the enterprise Linux vendor must deliver everything from enterprise-ready distributions to focused, appliance-like distributions that optimize the use of customers' favorite applications. And Linux vendors like Novell have answered the challenge, transforming Linux into a highly scalable, enterprise-caliber product that meets the demands of infrastructure services, workgroup computing and even mission-critical environments that previously relied upon proprietary operating systems. A global ecosystem—technical support, consulting expertise and training—is now also part of the value proposition.

Many customers are wondering, what is the future of Linux? Where is it going? What new technologies are emerging and how will they affect my business? As a leader in the Linux industry, Novell has the ability to impact the direction of Linux, and we obviously have our own thoughts about where the future of Linux lies. This white paper outlines our vision for the future of Linux—from the desktop to the data center.

Market Analysis

The Linux market is rapidly growing, and the operating system revenue from desktops, packaged software, and in particular, operating system software abroad servers running Linux is expected to exceed one billion dollars by 2011.¹ Modular, low-priced server hardware has raised the interest in Linux, and Linux is now the fastest-growing server operating system. IDC analysts believe that Linux growth will continue to mirror the growth of underlying server hardware. Intel-based servers running Linux or Windows* are leveraging both distributed and symmetric multiprocessing

(SMP) architectures, and hence are pushing into the traditional market dominated by RISC-based UNIX* servers. Linux on x86 hardware offers an inviting price/performance ratio when compared to UNIX on RISC hardware. And IT managers are increasingly convinced that Linux offers better total cost of ownership (TCO), reliability and flexibility than either UNIX or Windows. System integrators are expanding their capabilities for Linux, and aggressive marketing and R&D investments from Intel and AMD will accelerate the trend. As a result, it is expected that new UNIX implementations will decline.

Currently, Linux is most commonly used for Web serving and provides the infrastructure for database servers. However, Linux has emerged as mature, flexible and robust software supporting essential technologies for the data center. According to IDC, Linux server shipments will increase from 1.4 million units in 2006 to 2.4 million in 2011, representing a compound annual growth rate (CAGR) of 8.9 percent.² Because Linux receives more and more support from hardware and software vendors, the question of "whether" decision makers should consider Linux has shifted to "how" they are using Linux in the enterprise. In the future, Linux will prove its effectiveness in the areas of commoditization, modularization, manageability and virtualization.

A recent IBM-sponsored survey of readers of its *Open Source & Linux Line* newsletter confirmed the trend within the enterprise.³ Eighty-five percent of respondents are using Linux on their servers, especially at the largest organizations (5,000 or more employees), and 83 percent plan to implement new workloads on Linux during the next 12 months. Linux is regarded as an enabling technology for new business solutions.

Although it is also proving to be a solid and competitive desktop operating system, Linux has not achieved mainstream success in the desktop operating system market, where Windows still dominates. Gartner expects: “Windows will be the primary OS used on more than 80% of enterprise PCs in 2011 (0.7 probability).”⁴ Most of the existing applications are based on Windows, and Windows users are reluctant to change to unfamiliar systems. However, new trends in the desktop market will affect deployments in favor of Linux. Users are calling for greater reliability, cost efficiency and ease of use. Deployments will increase where applications do not rely on a particular operating system (e.g., Windows) and Windows applications.

IDC expects Linux client operating system new shipments will grow from 4.5 percent market share of worldwide to 6.7 percent in 2010.⁵ The main growth is expected to be in emerging markets, including parts of Asia Pacific and countries like Brazil, Russia, India and China where cost plays an important part. In addition, many governments have launched Linux projects.

Linux technology is similar to UNIX. Both operating systems are based on a core kernel, with an almost identical shell on top, file structure and surrounding utilities. Because of their common roots, moving from UNIX to the less-expensive Linux is a natural and manageable transition. Similar application development enables the transfer of applications from one platform to the other. Differences between the two operating systems do exist (such as the administration of UNIX and Linux), but Linux has proven its reliability, maturity and scalability. And Linux is at parity with UNIX for industrial strength. Because of its ongoing optimization, Linux is approaching UNIX leadership performance. Moreover, the compelling price/performance ratio associated with x86 hardware and the similarity between both operating systems will accelerate the adoption of Linux over

UNIX. For this reason, Linux is impacting the UNIX market more than Windows. The enterprise market will soon be dominated by two operating systems: Linux and Windows.

Freely available as well as low-cost Linux distributions remain a key element in Linux adoption. Cost will play a decisive role when considering Linux for non-mission-critical roles—basic infrastructure services like file and print, networking services and classic Web services. Low cost, flexible licenses and easy configuration are key criteria. But Linux will also continue to evolve, providing a key platform for everything from stateless desktops to personal and everyday devices. Linux is uniquely positioned, in terms of openness, innovation, community and support from companies like Novell, to leapfrog into these new opportunities where no solution exists today.

Desktop to Data Center Linux

With the introduction of SUSE® Linux Enterprise 10 in July 2006, Novell became the leader in Linux, providing the only desktop-to-data center solution. Novell calls this “enterprise Linux” because we focus not only on function, but also on the hardening and interoperability with other infrastructure technologies that are required if Linux is to be relevant to the enterprise.

With Linux gradually replacing UNIX for the reasons mentioned above, UNIX customers will demand interoperability between Linux and Windows. Interoperability reduces cost and helps customers get the most value from their IT investments.

The current Microsoft and Novell interoperability roadmap is the first step toward the future data center. The technology collaboration includes side-by-side interoperability (shared data), bottom-top interoperability (virtualization) and management of physical and virtual servers (directory and identity management), which together address significant problems enterprise customers face.

The current Microsoft and Novell interoperability roadmap is the first step toward the future data center.

4 Gartner Inc.: “Why the Client OS Matters Well Beyond 2011” by Michael A. Silver and Mark Driver, Aug. 28, 2006

5 IDC: “Worldwide Client and Server Operating Environments 2007–2010 Forecast and Analysis: Linux Establishes Itself Abroad Client and Server” by Al Gillen and Brett Waldman, Doc #205385, February 2007

Novell has made a firm commitment to Linux—from the desktop to the data center—through the SUSE Linux Enterprise platform.

On the desktop, any conversation about the broad adoption of Linux must begin with Windows interoperability. For customers to reasonably deploy a Linux desktop, that desktop must provide the ability to authenticate against Active Directory and share files with Windows desktops.

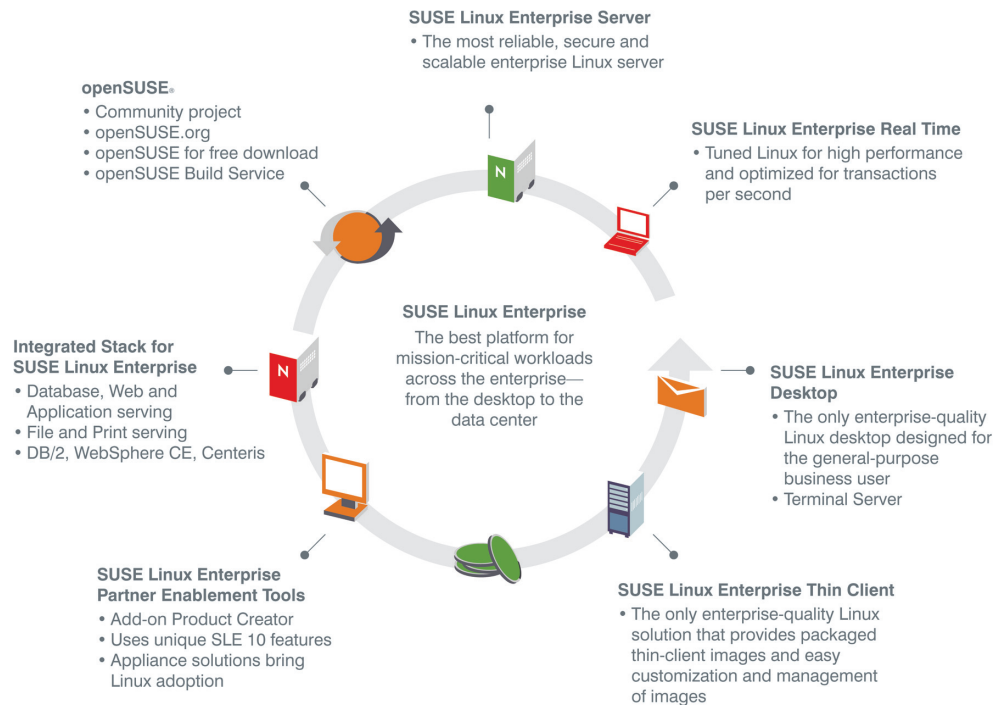
Virtualization—which will allow users to host Microsoft* Windows Server on SUSE Linux Enterprise Server and vice versa—will be the enabling technology for the consolidation of server workloads in heterogeneous data centers. Directory interoperability and identity management will enable clients from a variety of networks to register and gain access to services on multiple networks.

On the desktop, any conversation about the broad adoption of Linux must begin with Windows interoperability. As mentioned

earlier, while Linux is ready for broad desktop deployment—and Novell continues to lead the way with SUSE Linux Enterprise Desktop—the reality is that most enterprises have a broad deployment of Windows desktops. For customers to reasonably deploy a Linux desktop, that desktop must provide the ability to authenticate against Active Directory* and share files with Windows desktops. Again, this was one of the defining characteristics of the technical collaboration between Novell and Microsoft.

Novell has made a firm commitment to Linux—from the desktop to the data center—through the SUSE Linux Enterprise platform, which comprises the following products, all built from a common code base:

Novell Open Platform Offerings



- **SUSE Linux Enterprise Server**—*The best operating system to host mission-critical workloads in your data center*
- **SUSE Linux Enterprise Desktop**—*A general-purpose business desktop designed for use across your enterprise*
- **SUSE Linux Enterprise Real Time**—*A deterministic solution for time-critical applications*
- **Integrated Stack for SUSE Linux Enterprise**—*The lowest-cost, easiest-to-deploy, integrated stack for file/print and Web application/database serving*
- **Novell® Open Enterprise Server**—*A business platform that gives you the best networking, communications and collaboration services in the industry*
- **Novell Customer Center**—*An online interface where you can get technical support, product updates and subscription renewals for all your SUSE Linux Enterprise products*

The Future of Linux on the Desktop

Many of today's organizations run thousands of desktops and have to support a huge number of desktop applications. Because most of the desktop applications are running on Windows or depend on a Windows environment, the costs for license fees, maintenance, office productivity tools and new hardware have constantly increased. End users may enjoy the flexibility and multimedia functionality of Windows, but IT and business demand reduced hardware, software and deployment costs, better utilization of resources, enhanced application security and better desktop management. The trend in application development toward operating system-independent applications supports this evolution. Gartner, however, predicts: "...OS-agnostic applications will not represent 70% of applications being run until 2017".⁶ Developments around Web 2.0 (a concept addressed later in this paper) will continue the trend. Web sites

-serving complete applications to end users are expected to replace desktop computing applications for many purposes.

Against the background of those trends and requirements, advances in Linux on the desktop are developing along two related fronts: thin clients and desktop virtualization.

Thin Clients

The definition of "thin client" varies, depending on the organization in question. The phrase is sometimes used to describe a network computer without a hard disk, but most often, it describes a client whose software is managed and delivered by the network servers attached to it. Such a client rarely has its software installed locally. In all cases, thin clients are extremely limited devices. Most of the functions of the system are located on a central server so that the bulk of the data processing occurs on the server. The client itself has little or no application logic. The word "thin" refers to the small boot image and scarcity or lack of locally installed applications.

The benefits are obvious. Because thin clients are managed almost entirely at the server, IT administration as well as hardware costs are reduced. Centralized malware protection advances security management. In addition, thin clients only use the exact amount of resources required by the current task, which positively affects the network bandwidth and further reduces administration costs.

For organizations that are not ready to migrate to a complete Linux desktop, moving to Linux thin-client solutions can be an easy first step, providing immediate benefits. The benefits of thin clients combined with the strength of Linux in security, manageability, reliability and cost-effectiveness make a strong case for migration to Linux.

End users may enjoy the flexibility and multimedia functionality of Windows, but IT and business demand reduced hardware, software and deployment costs, better utilization of resources, enhanced application security and better desktop management.

⁶ Gartner Inc.: "Why the Client OS Matters Well Beyond 2011" by Michael A. Silver and Mark Driver, Aug. 28, 2006

SUSE Linux Enterprise Server 10 is the best example of why customers are choosing Linux for their enterprise.

-
- 7 Forrester: "Desktop Virtualization Is The Future Of The Corporate PC," by David Friedlander and Simon Yates, January 2006
 - 8 Gartner, Inc.: "Defining Virtualization for the PC," by Brian Gammage, June 7, 2006

The acceptance of thin clients running on Linux is consistently growing, especially in domains where users work only with one or more applications, such as retail outlets, call centers and help desks, or where access to IT support is limited. But governments, manufacturing firms and financial services institutions also consider thin clients to be compelling desktop solutions. The market in 2007 has already shown a significant swing toward the thin-client model for enterprise application development and deployment. This trend extends to the point of delivering an entire "virtual desktop" (or "desktop in the data center"), as we discuss below.

Desktop Virtualization

Forrester defines desktop virtualization as "a PC environment where some or all components of the system, including operating system and applications, execute in a protected environment, isolated from the underlying hardware and software platform."⁷ A central server hosts pre-built and fully configured operating system images. A virtualization layer provides the connection between the virtual desktop environment and the rest of the system, and allows the user to run separate desktop operating systems simultaneously on a single PC, with each image having its own network connection if necessary.

The desktop virtualization market is growing, driven by many factors. Many companies regard virtual desktops as an efficient and secure technology for mobile employees. Users are still able to personalize their desktops. However, standard configuration and centralized, virtualized desktop environments in the data center help IT and business to reduce the costs for desktop support and provide system stability and reliability. These virtualized desktops also improve security for applications and data and simplify overall deployment.

Processor vendors such as Intel and AMD have already started to include virtualization

technology in PC processors and chipsets. A software program will run directly on top of the hardware ("hypervisor"), optimizing desktop virtualization by providing the platform necessary to run several operating system images as virtual machines on a desktop. One of those technologies is the Xen* hypervisor open source project. With support from vendors such as Novell, Intel, AMD, IBM and others, the Xen hypervisor delivers performance, flexibility and security to the virtualized environment. According to industry experts, desktop operating systems as we know them will change in the near future.

"Gartner expects this technology (PC virtualization) to become viable for mainstream users from 2009."⁸

The Future of Linux on the Server

As mentioned earlier, Linux has mainly been used as a server operating system. It is becoming a mainstream server operating system in organizations of all sizes, and in all markets, worldwide. Good examples are Linux servers in combination with Apache, MySQL* and Perl/PHP/Python (LAMP) or used as an operating system for super-computers. (Around 75 percent of the top 500 systems run on Linux.)

The cost, reliability, stability and ease with which the software can be customized, installed and operated is quite appealing to organizations. In addition, the fact that hardware vendors such as IBM and HP provide support for Linux gives IT managers the confidence that technical and maintenance issues will be addressed. More and more businesses are considering Linux servers for high-performance tasks as well as for mission-critical business applications from vendors like SAP and Oracle.

SUSE Linux Enterprise Server 10 is the best example of why customers are choosing Linux for their enterprise. It is a massively

scalable (using several commodity server platforms or one, large symmetric multiprocessing server, according to organizational needs), highly available solution. It also features fully integrated management tools at no extra cost that make it easy to configure storage for mission-critical workloads.

The future of Linux on the server lies in server consolidation and migration. Existing and new server resources will be used more efficiently. And because it can run in symmetric multiprocessing environments, as well as on commodity architecture servers such as Intel-compatible 64-bit servers, Linux is also seen as an enabling technology for new sets of business solutions. Linux will take the lead in driving high-performance commodity IT environments supported by the following major technologies:

Virtualization

There is industry-wide focus on reducing the TCO of the enterprise computing infrastructure. In order to keep businesses both agile and profitable, CIOs and IT managers must deliver improved services at a reduced cost, while also rapidly aligning IT services with overall business strategies for flexibility in supporting new business initiatives. Virtualization is fundamental to these tasks, and thus has found its way into the IT infrastructure.

Virtualization is the hot topic in enterprise IT today—and with good reason. Data center managers who use virtualization make far better use of their compute resources than managers who run non-virtualized environments. This is because virtualization allows a single machine to run multiple operating systems at the same time.

Virtualization pools IT resources in a way that masks the physical nature and boundaries of those resources from resource users. In more concrete terms, virtualization is the decoupling of software from hardware—the underlying implementation—so that software can “live”

independently on the same physical hardware. In the server architecture, virtualization can take place between the application and operating system (such as with middleware clustering or containers) or between the operating system and hardware (creating virtual machines). With regard to Linux, we will concentrate on the latter.

Virtualization is the hot topic in enterprise IT today. Data center managers who use virtualization make far better use of their compute resources than managers who run non-virtualized environments.

independently on the same physical hardware. In the server architecture, virtualization can take place between the application and operating system (such as with middleware clustering or containers) or between the operating system and hardware (creating virtual machines). With regard to Linux, we will concentrate on the latter.

Virtualization of the operating system is not a new innovation. In 1972, IBM's partitioning of the System 360 mainframe reduced hardware costs and increased overall utilization. Today, enterprise IT managers can address all of the following challenges using virtualization technology:

- **Hardware costs.** *With virtualization, IT managers can lower costs by reducing the number of physical servers maintained.*
- **Server containment.** *Server consolidation reduces the physical space and power requirements.*
- **Increased server utilization.** *By allowing multiple applications to coexist on one physical server, virtualization enables more efficient use of resources and harnesses more of each server's capacity, increasing server utilization.*
- **Test and development optimization.** *Running multiple operating systems on a single computer enables an organization to pursue more in-depth development and testing, and to take on additional projects.*
- **Business continuity.** *A virtual machine and its applications can be easily relocated to and stored in an alternative location or on a remote target server, minimizing downtime and maintenance costs.*

The future of Linux on the server lies in server consolidation and migration. Existing and new server resources will be used more efficiently.

IDC predicts that Linux will capture 36.3 percent of the overall virtual machine software market by 2010, and that virtualization will be tightly integrated with the base operating system.

-
- 9 IDC: "Worldwide Virtual Machine Software 2006–2010 Forecast," Doc #203213, September 2006
10 IDC "Worldwide System Infrastructure Software 2007 Top 10 Prediction," Doc #204567, December 2006

- **Flexibility and scalability.** *Virtual machine images can be deployed automatically on existing hardware to add more processing power at peak demand times. IT teams can respond more rapidly and flexibly to business requirements for new IT resources.*

Virtualization is achieved by inserting a layer of software between the operating system and the underlying hardware. The primary virtualization technology of choice is a virtualization layer known as the hypervisor, mentioned earlier.

Two types of virtual machines have gained credibility:

- **Full virtualization.** *This type features a virtualization layer that mediates access to hardware resources and permits multiple operating system instances to coexist on a single server. It does not require modification of the guest operating system. However, this mediating layer requires a virtual machine to trap and emulate all privileged instructions, and performance can be negatively affected.*
- **Paravirtualization.** *In this type, a "guest" operating system is aware that it is running within a virtualized environment and has been modified to exploit this.*

The first operating system to emerge with integrated virtualization is SUSE Linux Enterprise 10 from Novell, which incorporates the open source, modular Xen virtualization technology. Many key processor vendors and system vendors have announced their support for Xen.

The recently announced collaboration between Microsoft and Novell will significantly broaden deployment of virtualization. As mentioned earlier, the companies will begin by improving virtualization technologies to enable Windows to run as a virtual operating system on top of SUSE Linux Enterprise, and vice versa. Virtualization will allow IT systems to benefit

from both operating systems, while enabling greater opportunities for hardware choice and interoperability.

Hardware vendors like Intel and AMD will boost virtualization technology. New processor technologies, such as the Intel VT* and AMD-V* chips, will support virtual machine solutions, such as Xen from Novell, at a hardware level for better performance. They will make these solutions more efficient, robust, secure and flexible to use.

IDC predicts that Linux will capture 36.3 percent of the overall virtual machine software market by 2010, and that virtualization will be tightly integrated with the base operating system.⁹ Three virtualization technologies are expected to dominate the market: the Xen hypervisor, the VMware* platform and the Microsoft Viridian hypervisor.

Software Appliances

In December 2006, IDC released its top ten predictions for the infrastructure software market in 2007.¹⁰ One of those predictions is: "Software appliances will become a household word in 2007. The convergence of virtual machine technology and a new initiative by several tool vendors is giving birth to this new form of software packaging."

A software appliance is a software application combined with an unmodified or purpose-built operating system such as a file server or application server. The application runs on top of the operating system. In some cases, software appliance vendors may install the software appliance on a piece of hardware prior to delivery to the customer. Thus, the appliance is enterprise ready because the software is maintained and supported by the software appliance vendor.

The value for the customer is evident: pre-packaged software is limited in functionality and is therefore less expensive to acquire and easier to manage and replace. The license

model and service contracts are also simplified compared to traditional deployments where applications, operating system and hardware all might have different support structures.

For application providers, software appliances offer an unequalled opportunity to expand the market for their software. The general-purpose nature of the operating system is no longer a consideration. Most of the operating system-related configuration can be completed and shipped by the appliance vendor, eliminating many complicated setup and configuration procedures. Thus, software appliances become more accessible to potential buyers.

Traditionally, there was one significant downside to software appliances that hindered broadening of the market: because the software appliance is a complete software stack, only one software appliance at a time could be deployed on one piece of hardware. For security software in particular, such as firewalls, this was never considered a real problem because it increased the number of security stacks actually sold as appliances. Thus, if the downside is eliminated for other workload areas, the software appliance market will likely broaden in many directions and penetrate those new areas.

Virtualization technology removes the traditional downside of software appliances. Thus, the increasingly broad adoption of virtualization solutions will support the acceptance of software appliances.

Virtual appliances are a subset of software appliances. A virtual appliance is a minimalist virtual machine image designed to run under a virtual machine monitor like Xen. For example, a user can easily download a new virtual appliance to update his application. Like software appliances, virtual appliances are limited-function, self-contained software that is easily and inexpensively acquired and replaced. Software appliances coupled with

virtualization provide more market expansion and license sales growth through dramatically simplified deployment and maintenance.

In a longer-term view, this might result in major changes. The customer visibility of the operating system will decline or disappear. At the very least, the specific Linux distribution will no longer matter. For this reason, winning in this new market situation requires operating system vendors to provide the best ways for software and hardware vendors to integrate with, customize and support the embedded operating system. And ease of management will increasingly factor into which appliance solution larger enterprises choose.

The portability, flexibility and customizable nature of Linux have made it the first choice for software appliances. It is expected that leading Linux vendors like Novell will bring forward a competitive appliance strategy and boost the deployment of software appliances.¹¹ SUSE Linux Enterprise will set a course in this market by providing the best virtualization host and the best appliance service offering. With SUSE Linux Enterprise 10, Novell has already started to allow for easier operating system customization, which is a perfect improvement for appliance vendors who want to customize as much as possible without losing support on the backend. Novell will invest in this area and provide further improvements to perfectly match customers' needs.

Embedded Linux

The number of devices with embedded intelligence is growing exponentially, and with them the demand for an integrated operating system. Embedded Linux is a Linux-based operating system that is encapsulated by or dedicated to a device or system. It is included in commercially available products or hardware—such as cell phones, media players, firewalls, industrial control systems and other devices. Its functionality is limited to the requirements of the device.

The portability, flexibility and customizable nature of Linux have made it the first choice for software appliances. It is expected that leading Linux vendors like Novell will bring forward a competitive appliance strategy and boost the deployment of software appliances.

¹¹ IDC: "Software Appliances: After a Long Engagement, Applications and Operating Systems Finally Get Hitched," Doc #205355, January 2007

The data center of tomorrow will be more consolidated, highly utilized, better designed, fully redundant and very dynamic.

12 IDC: "Worldwide Operating Systems and Subsystems 2007–2011," Forecast by Al Gillen and Brett Waldman

The embedded software market is growing steadily due to growth in consumer electronics, especially in mobile and wireless products. IDC expects that the embedded operating system market will grow from US\$461 million in 2006 to US\$532 million in 2011. As a result, embedded operating systems could achieve a 1.9 percent share of the overall operating system market.¹²

Due to its scalability, configurability and affordability, embedded Linux has become a highly desirable operating system for embedded design. Although Novell is currently not focusing on embedded Linux, it is a market to watch.

The Future of Linux in the Data Center

Data centers have evolved from mainframe environments to highly flexible, mixed environments with clusters and distributed computing. Increased productivity and capacity within the existing computing infrastructure also mandates increased power consumption, space requirements and cooling needs. To compensate, the data center of tomorrow will be more consolidated, highly utilized, better designed, fully redundant and very dynamic. Two trends will dominate:

- **Server consolidation using virtualization.**

Combining workloads from underutilized servers or applications onto a smaller number of Linux servers can reduce data center space requirements as well as power and cooling costs—leading to the efficient use of server resources. Server consolidation using virtualization is one of the most effective ways to lower the TCO of a company's data center.

- **Compute servers.** *Using servers with multi-core, 64-bit CPUs, multi-GB memory, serial-attached RAID and so on (rackmount and blade) will also reduce the amount of physical space necessary in the data center. To support the increase of perform-*

ance per watt, Novell is currently working on a project designed for lower power consumption in combination with SUSE Linux Enterprise running on a multi-core architecture. Compute servers run an appropriate operating system for the physical hardware architecture comprising a virtual machine monitor (such as Xen hypervisor), device drivers, the management kernel and agents. Currently, the dominant blade operating system is Linux. As the operating system that offers the most value via physical space savings, it is expected to maintain its position.

While virtualized resources help enterprises meet their growing capacity needs, they also pose serious new management challenges. The decision to deploy a virtualized environment is easy, but it can be challenging to select the tools and services required to manage such an environment. Virtual servers, like physical servers, must be configured. And even if there are fewer physical servers to manage, all of the virtualized servers still require management attention. These challenges force data center managers to look for automation solutions that can help address the problem. These automation solutions need to include deployment, changes, security, consolidation, migration, disaster recovery and resource reallocation.

Virtualization in the Data Center

Currently, the most likely environment for server virtualization is test and development, followed by file and print servers, Web servers and infrastructure servers. However, more and more data center managers are considering aggressive implementations of server virtualization, realizing that virtualization will help them reduce space, power and cooling needs as they work to avoid hitting data center limits or expansion thresholds. Because virtualization is maturing rapidly, two virtualization technologies will have a huge impact on data center infrastructures:

- **Virtual machine—hypervisor.** *Hypervisor-based virtualization is regarded as a strategic technology in the data center. Although the entry area is server consolidation, increased hardware utilization and reduced hardware cost, hypervisors will be the key enabling technology for disaster recovery solutions, downtime management and capacity planning.*
- **Virtual machine relocation.** *Relocation capabilities can be used to move a virtual machine (e.g., a running guest operating system) from one server to another, achieving dynamic load balancing. Benefits are reduced planned downtime and a much faster response to changing scaling requirements. Gartner expects: "Virtual-machine relocation will become a default technology for most large x86 server infrastructures within five years, and it will dramatically change how servers are managed—disaggregating operating-system instances from physical servers."¹³*

Server virtualization in the data center leverages faster deployments, reduced downtime, disaster recovery and usage charge-back. "Roughly 80% of Gartner clients who are deploying x86 virtualization also plan to leverage virtualization for disaster recovery—either as a source capture solution, as a target solution or both. Because most x86 servers do not have any disaster recovery support today, this is a net add in hardware sales."¹⁴ Decision makers are learning that a Linux solution exists for most of their computing challenges and should be part of their holistic capacity planning. Novell sees virtualization as a tremendous opportunity for its data center customers. Novell envisions virtualization-enabled data centers in which there is highly sophisticated integration of components that are largely isolated today.

Desktop in the Data Center (Virtual Desktop)

Desktop in the data center, also known as virtual desktop, is about deploying and

consolidating desktop environments through centralized management. Since the introduction of personal computers, administrators of large desktop deployments have faced many difficulties in managing their machines. Support costs for each desktop are increasing. In addition, companies worry about patches, updates and virus protection.

Centralized management of desktop systems enables faster deployment time and more predictable performance. And with virtualization and other enabling technologies, a number of new deployment methods have been developed:

- **Server-based (thin-client) computing.** *As discussed earlier, Linux images with few if any installed applications are hosted centrally and periodically published to a variety of client devices. End users of thin clients access applications and data residing in the data center. As a result, companies gain better security, easier management and reduced ownership costs.*
- **Blade PCs.** *The entire desktop instance is running in a chassis in a blade server configuration, with one blade for each end user. The user's thin client has remote access to the complete desktop environment, which maintains full state. While reduced support costs, sense of ownership and system performance are key advantages, the hardware costs for a blade/client combination can be a deterrent.*
- **Stateless client.** *A stateless Linux client mounts an image containing the operating system as well as the configuration files at boot time. A Linux master instance is deployed over the network, including all information about the Linux setup. The setup information will be stored as read-only, so the system remains fixed as its administrator configured it.*

Because companies will increasingly strive to reduce maintenance costs, the future differentiation criteria for desktops in the

Novell sees virtualization as a tremendous opportunity for its data center customers. Novell envisions virtualization-enabled data centers in which there is highly sophisticated integration of components that are largely isolated today.

-
- ¹³ Gartner Inc.: "Virtualization: Taking Charge of your Servers," by Thomas Bittman, Gartner 25th Annual Data Center Thomas Bittman Conference 2006, Nov. 28–Dec. 1, 2006, Rio All-Suite Hotel & Casino, Las Vegas, NV
- ¹⁴ Gartner Inc.: "Why the Client OS Matters Well Beyond 2011" by Michael A. Silver and Mark Driver, Aug. 28, 2006

The Novell approach puts Novell into a leading position in data center automation and management.

Because the overall share of Linux continues to grow and customers want Linux solutions that provide the same functionality that Windows does, Novell and SUSE Linux Enterprise will continue to influence the market.

data center will be manageability, security, automation and reliability. In addition, centralized administration ensures private and sensitive data is protected in the data center. While the market is still young, companies are familiarizing themselves with the enabling technologies. Major players in this market will be those vendors that can leverage management and support tools and provide a complete portfolio. Novell has already spent considerable time creating solutions covering the enterprise from the desktop to the data center. Because the overall share of Linux continues to grow and customers want Linux solutions that provide the same functionality that Windows does, Novell and SUSE Linux Enterprise will continue to influence the market.

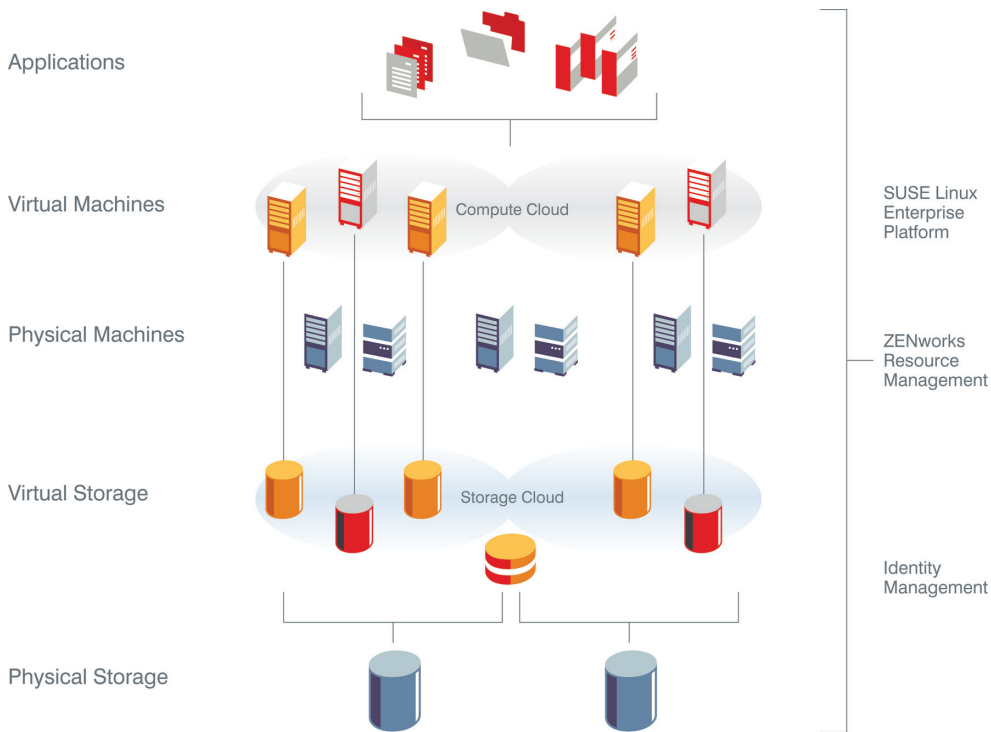
Data Center Automation and Management

Data centers are becoming a very important place, and a place of differentiation. They are required to be high-quality, high-performance environments that reduce TCO, increase security and deliver the extraordinary performance necessary to handle a huge amount of data every day. In addition, data centers have to keep up with dynamically changing business requirements. Administrators struggle with ever-increasing complexity and the requested flexibility in the data center. These challenges force data center managers to look for automation solutions that can help address the problem and prevent data center chaos.

The modern data center comprises virtualized computing and storage controlled by distributed operating systems. Virtualized applications and data are distributed among

existing computing resources for processing, which eliminates physically imposed static boundaries, optimizes physical resources and facilitates the use of alternate physical resources while adapting to workload demand. However, virtualized systems do nothing by themselves. They can compute and store data in a very dynamic way, but will not do so unless directed to. The key to success will be management software components that orchestrate the provisioning, configuration and allocation of hardware and software resources. The automated data center of the future should be able to respond to hardware failures by recreating services on backup equipment. In addition, policy-based automation enables 24x7service by allowing the data center to respond to individual conditions quickly and efficiently, while minimizing management costs.

With Novell ZENworks® solutions, customers can automate IT data center operations using dynamic, policy-driven solutions that ensure security and compliance, eliminate administrator effort and enable total control over the IT environment from the desktop to the data center. Four new solutions from the Novell ZENworks systems and resource management family provide a complete set of integrated Information Technology Infrastructure Library (ITIL)-based services that automate management across diverse server and client platforms for both physical and virtual environments—including Xen virtualization on Linux—and automate the load balancing of these machines. Data center managers can use standard servers and storage running SUSE Linux Enterprise 10 to configure a clustered environment that is free of a single point of failure. The Novell approach—which links virtualized storage, virtualized machines, resource management and Services Oriented Architecture (SOA) applications—puts Novell into a leading position in data center automation and management.'



Systems management solutions from Novell provide open standards-based management that covers the entire enterprise IT environment, from Linux to UNIX to Windows, and helps customers maximize the value of their technology infrastructure.

Because the data center is evolving so quickly, with ever-increasing demands for uptime and the introduction of new technologies, the future of Linux in the data center relies not only on enabling technologies but also on the ability of Linux to integrate with the comprehensive set of data management tools that will orchestrate the management of virtual machines, high-performance computing and other IT resources.

In a future data center where Linux and Windows are the dominant operating systems, Novell ZENworks will answer customer calls for interoperable solutions. Systems management solutions from Novell provide open standards-based management that covers the entire enterprise IT environment, from Linux to UNIX to Windows, and helps customers maximize the value of their technology infrastructure. Future versions of SUSE Linux Enterprise will develop along these lines,

with the integration of a comprehensive set of management and business tools.

Real-time Performance

Many of today's largest high-profile organizations—including financial institutions, manufacturers, government agencies and others—rely on time-dependent applications and processes, which must execute accurately and predictably all the time, every time. Real-time, or deterministic, performance generally refers to “hard” real time—the ability to ensure that certain processes are always completed within a specifically determined length of time, measured in milliseconds or even microseconds, regardless of other system activities or traffic. Within that determined time, the CPU must acknowledge an interrupt (software or hardware request for service), stop the task it was doing (if the new interrupt is of higher priority), save the state of that task for later use and then start the new

The Novell data center strategy will enable customers to take advantage of the key benefits provided by Linux and open source.

process that was requested. Hard real-time performance has been around for many years, and is an enabling technology for many important application areas like computer systems in aircraft training simulators, agile manufacturing, defense systems, medical applications, financial applications and all other systems where safety is critical.

Businesses are starting to realize the value of real-time performance in their applications, particularly in the financial sector where deterministic performance can guarantee that every transaction is completed within a given timeframe regardless of system activity or load. The commercial market for real-time operating systems has already reached US\$100 million, and multi-core and multi-processors servers have accelerated the trend. New real-time trading applications in the financial sector, such as Algorithmic Trading and Real Time Enterprise Risk Management, were key business drivers for real-time Linux in the enterprise, which emerged in 2006. Some of the future challenges of real-time Linux will be the development of independent real-time applications that can coexist on the same machine or set of machines, and the catenation of real-time and non-real time systems.

Latency matters. It's the difference between mere survival and the ability to compete aggressively in a continuously demanding market. An ideal real-time solution for time-critical systems should be fast and predictable, even when processing heavy workloads. It should guarantee consistent high performance with low latency, and should be fully supported by a world-class support ecosystem. SUSE Linux Enterprise Real Time is a low-risk, high-performance, real-time Linux solution for complex time-critical applications, and is fully backed by the award-winning Novell support team.

Strength and Flexibility

Linux offers the data center a wide variety of application choices. It runs on the IBM* z90 mainframe as well as commodity hardware

based on an Intel* architecture. It runs on servers and desktops, and is the operating system of choice for clusters. No other operating system provides the same range of options in the data center. Companies want to improve data center operations, and they want to be confident that their operating system will be compatible with their future growth plans. SUSE Linux Enterprise has the industrial strength to handle mission-critical loads in the data center. It includes:

- *Testing, reliability and high availability*
- *Improved data center manageability*
- *Better utilization of data center resources through virtualization*
- *Increased application scalability and performance to scale very large workloads*
- *Performance*
- *Longer life for business-critical legacy applications*
- *Increased stability and security of data center resources and assets*
- *Flexibility and portability across multiple processor architectures*

The Novell data center strategy will enable customers to take advantage of the key benefits provided by Linux and open source.

Excursion: Linux and Web 2.0

The Web is experiencing a period of change. The number of services is changing, as is the way these services are offered. The term for this social and technology evolution is Web 2.0. Rather than an official definition of a standardization body, it is a set of software development tools and technologies combined with new models for community and collaboration. Web 2.0 is a synonym for "dynamic Internet computing," with Web sites and Web applications that allow the sharing and exchange of data and information online. Technologies like blogs and wikis are just some popular examples of how Web 2.0 is already used. It creates innovative ways for businesses to operate and people to communicate.

With Web 2.0, the PC is reduced to a local cache and control station hosting the browser, which is the interface to the Web applications. The new Web applications are not hosted on a single server; rather, they are composed of services provided by multiple computers. They will span multiple devices that are all connected to the Web platform. The Web platform, comprising Web 2.0, compute, storage and information and messaging services, will become an almost invisible part of the infrastructure. As a result, the big challenges for enterprises will be integration with enterprise data and application performance and management.

So, what is the impact on Linux when more and more applications move onto the Web and the underlying operating system becomes less important?

- *The traditional desktop will shift toward a more modular operating system architecture with a focus on Web enabling. The underlying complexity of the operating system will be hidden from the user. Whereas in the past, software applications ran on the user's machine, handled by a desktop operating system such as Linux, software services will now run purely within the browser itself, communicating with the network and remote systems. Data and applications will be stored on Web servers, and users will access those from any device with a Web browser.*
- *Operating systems will incorporate Web 2.0 technologies such as Really Simple Syndication (RSS), a suite of Web formats and key development tools, services and environments for the Web 2.0 infrastructure.*
- *A new kind of operating system is emerging: Web operating system (WebOS) provides an operating system as well as network services for Web-based distributed computing. It runs over browser windows or plug-ins on top of existing operating systems, is independent from the traditional individual operating system and includes mechanisms*

for naming, persistent storage, remote process execution, resource management, authentication and security.

Novell has already taken the first steps toward Web 2.0. SUSE Linux Enterprise Server 10 includes Web 2.0 tools and services such as Apache Web Server, Perl, Python, PHP, MySQL, PostgreSQL, Ruby, Geronimo, Apache Tomcat and many others.

Looking Ahead

Linux is the smart, open operating system of choice for business today and in the future, from the desktop to the data center. So, what's next for Linux? Linux developer and user communities tend to drive Linux. There is no roadmap for the Linux kernel, and it's unclear what shape it will ultimately take. However, advancements in Linux server technology during the upcoming years will certainly increase the market share of Linux operating systems. Input from both independent and corporate software developers will lead to innovations. And UNIX vendors, independent software vendors (ISVs) and the Linux open-source community will evolve the kernel in terms of reliability, performance and integration.

The growth will only continue. Computing power will increase rapidly within short periods of time. Virtualization in server hardware and operating system software will accelerate the trend of optimized computer utilization, as companies continue to seek improvements in price/performance. Much of the growth in Linux deployments will come through increasing workloads. And because the future IT environment is mixed, interoperability, mainly with Microsoft, is fundamental to the success of enterprise Linux.

Novell has already recognized the future trends and announced the first offerings of its management initiative—spanning the desktop to the data center—including the availability of a comprehensive set of solutions

Advancements in Linux server technology during the upcoming years will certainly increase the market share of Linux operating systems.

Novell desires to provide the world's best and most interoperable Linux operating system, surrounding it with management services that leverage considerable experience and expertise to help solve customer problems with heterogeneous environments.

that orchestrates the management of virtual machines, high-performance computing and other IT resources. Systems management solutions from Novell provide open standards-based management that covers the entire enterprise IT environment, from Linux to UNIX to Windows, and helps customers maximize the value of their technology infrastructure. These solutions are also well positioned to help organizations more closely align IT with their business needs, control costs and minimize risk. The agreement with Microsoft emphasizes the vision Novell maintains of interoperability and cross-platform management solutions.

Novell desires to provide the world's best and most interoperable Linux operating system, surrounding it with management services that leverage considerable experience and expertise to help solve customer problems with heterogeneous environments. Future SUSE Linux Enterprise versions will provide innovation in the areas of virtualization, interoperability and systems management. And because large businesses will increasingly use Linux in mission-critical applications, the virtualization input will grow over the upcoming years to include security and management tools.

Although Linux on the desktop is experiencing rapid growth, the opportunity still lies on the

server side for Linux. Windows dominates the desktop market, and will beyond 2011. However, the market share of Windows is declining. When budgets are tight and security is a concern, companies look for a powerful and cost-effective thin computing alternative. Consolidating desktop environments in the data center is one of those alternatives. Developing applications that do not depend on the operating system or run only as Web applications is another. Due to its flexibility, Linux is the perfect operating system to accelerate both trends.

Future versions of SUSE Linux Enterprise Desktop will leverage the trends. For transactional and fixed-function applications, Linux is already mainstream today. For general office workers, SUSE Linux Enterprise Desktop will accelerate the deployment of Linux to knowledge workers. Over the next few years, companies that are taking advantage of Linux in the data center or using it to host corporate applications will start to deploy Linux desktops aggressively. The Linux desktop will be easily integrated into a corporation's overall Linux implementation, saving time and resources while leveraging the same set of IT skills.

Finally, Novell will drive further innovation to deliver complete Linux solutions for business infrastructure, from the desktop to the data center.

www.novell.com



Contact your local Novell
Solutions Provider, or call
Novell at:

1 800 714 3400 U.S./Canada
1 801 861 1349 Worldwide
1 801 861 8473 Facsimile

Novell, Inc.
404 Wyman Street
Waltham, MA 02451 USA