



UNIX-to-Linux Migration: An Introduction

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Abstract

This paper is intended to provide a discussion of the important considerations, best practices and resources for migrations from a RISC-based platform to Linux. The differences between UNIX and Linux are presented, and an overview of what to expect when migrating to a Linux is provided. The document should serve as a general reference guide for customers considering migrating to Linux and provide information on additional Red Hat resources that will assist with the overall strategy and implementation.

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Introduction

As enterprise customers have become frustrated with the price and performance of proprietary UNIX solutions, they have sought a way to take advantage of the multi-vendor, low-cost, high-performance environment provided by Intel's x86 hardware. Historically, the lack of a stable, secure, scalable, and high-performance operating environment relative to UNIX has kept many customers from being able to justify a move to the Intel chipset. Even those customers willing to accept the limitations of the Windows operating system running on Intel hardware have faced a very tough migration, porting, and integration effort. Such cost and effort poses a significant barrier to entry. UNIX variants have been released for the Intel platform, but none of them have been able to provide adequate hardware support, software support, or scalability to make Intel an effective alternative to RISC-based platforms. Now, as a product of the continual improvement of the Intel platform and the rapid development of the Linux operating system, there is finally a viable alternative to UNIX for running enterprise and mission-critical applications. Linux is now the fastest growing operating system in the world, according to IDC, and it is most often replacing proprietary UNIX in enterprise IT infrastructure. This paper outlines the basic differences between Linux and UNIX, and provides information to make informed decisions about where Linux may replace UNIX in the enterprise today.

What is Red Hat Enterprise Linux?

Prior to the release of Red Hat Enterprise Linux AS 2.1, the Linux marketplace was a very difficult one for Independent Software Vendors (ISVs) in general and database vendors in particular.

The open source development model has historically been driven at an extremely rapid pace. For example, in just 18 months Red Hat released Red Hat Linux 7.3, 8.0, and 9. This model was vastly different from the much longer release cycles prevalent in the proprietary operating system space and was not in line with the development models many enterprise application require.

Red Hat developed Red Hat Enterprise Linux as the single target platform for all major ISVs and their enterprise-level server applications to alleviate the burden the previous development cycle was putting on software development companies. With Red Hat Enterprise Linux, Red Hat provides a platform that both ISVs and system administrators can support. Red Hat Enterprise Linux AS 2.1 first became available in May 2002. Red Hat also released Red Hat Enterprise ES and Red Hat Enterprise Linux WS shortly thereafter to complete the product line with distributions appropriate for mid-range server applications and technical workstations. Red Hat Enterprise Linux is released every 12-18 months, giving ISVs more time to certify and deliver their products. Red Hat Enterprise Linux version 3 became available in October 2003. The next version of the Red Hat Enterprise Linux product line will become available in early 2005. All versions of Red Hat Enterprise Linux will be maintained by Red Hat for five

years after the initial creation date. Red Hat Enterprise Linux products are available to customers through annual subscriptions, which include maintenance and support as well.

Red Hat Enterprise Linux is also a more focused environment than the retail Red Hat Linux products or the community-driven Fedora Project. The Red Hat Linux product line has run its course and is no longer available or maintained by Red Hat. The Fedora Project picked up where Red Hat Linux development left off. Fedora Project is an endeavor through which Red Hat works with the open source development community to build, test, and eventually integrate packages into its official releases. Packages the community tests and deems stable will likely undergo extensive internal QA and become part of Red Hat Enterprise Linux. The Fedora Project contains a variety of technologies and applications that are either not business related, or are still in the process of development. In contrast, the packages that comprise Red Hat Enterprise Linux have been included for their stability and applicability to a production enterprise environment.

The longer release cycle for Red Hat Enterprise Linux does not mean that system administrators must sacrifice the timely release of security and bug fix updates they have come to expect from Red Hat. Bug fixes and security updates will be released on an as-needed basis to ensure that customers have the most reliable, stable, and secure systems possible. These updates will be made available through Red Hat Network, which enables the easy deployment of updated software to a large number of systems. The intent of the Red Hat Network is to reduce administrative overhead for corporate system administrators by simplifying and centralizing package management and system maintenance at an affordable cost.

More information on the current Red Hat Enterprise Linux product line is available at <http://www.redhat.com/software/rhel/>

What is open source?

The term open source refers to the practice of distributing the source code of an application as well as the binary (compiled) version. This allows the user to make modifications to the code and improve it any way they see fit. Red Hat is firmly committed to open source because it allows a level of innovation that is light years ahead of the proprietary software development model. With thousands of programmers able to contribute to the operating system, including developers and system administrators inside our enterprise customer accounts, we are able to facilitate rapid enhancements in functionality, performance, reliability, and security that take proprietary vendors years to achieve. There are a number of popular open source licenses, including the GNU General Public License and the BSD License. Some of Red Hat's competitors have criticized open source licensing as an inhibitor to innovation. These criticisms distort the

meaning of the open source licenses and exaggerate the instances in which the GPL impacts the licensing scheme adopted by application vendors. In the overwhelming majority of cases, such as the Oracle database, vendors successfully support their applications on Red Hat Enterprise Linux under the proprietary licensing model familiar on Windows and UNIX. The section of this paper entitled “*Proprietary Applications Porting and Development*” clarifies the impact that open source licenses in Red Hat Enterprise Linux have on the licensing of software.

What is Red Hat's business model?

Red Hat has built a profitable business with open source software. Red Hat's business plan is to derive the majority of its revenue from subscriptions associated with the development, deployment, support, and management of Linux in enterprise environments. The latest market analysis indicates that the line between software and software related services is blurring as a consequence of the high degree of connectivity of today's systems. Additional information on the full range of services provided by Red Hat is included in the section of this paper entitled, “*Supporting Linux in the Enterprise.*”

Operating system differences

Although Linux is basically a UNIX-like operating system, there are a number of subtle differences between Linux and UNIX. Few of these differences have a significant impact on the end-user experience or application functionality, but it is important to understand what differentiates Linux from UNIX to help determine where to utilize it in the enterprise.

Basic UNIX Infrastructure

With a basic infrastructure similar to UNIX, Red Hat Enterprise Linux consists of a kernel that handles all hardware and device interaction as well as all job scheduling. Surrounding this kernel are all of the user-space applications, many of which are the same or similar to those found in the base UNIX installations. Linux can be run in text or graphical mode as with UNIX, and the graphical mode is supplied by the XFree86 X Windows interface.

Like UNIX, Linux comes standard with a large selection of built-in applications to allow it a high base level of functionality. Tools for working in a networked computing environment such as BIND, NFS, FTP, Telnet, SSH, rsh, and a number of other applications are distributed with the core operating system itself.

Open Source Tools

Unlike UNIX, Red Hat Enterprise Linux is shipped with a huge repository of open source software that provides compliments to, or direct replacements for, third-party ISV applications available on other operating systems. For many users these applications have proved to be adequate surrogates to some of the tools they have previously had to purchase; others have felt more comfortable simply using the Linux version of their existing ISV applications. Examples of such open source applications include Apache for Web serving, Sendmail for mail transfer, CVS for source code management, and PHP for active Web applications.

Filesystem

All versions of Red Hat Enterprise Linux use EXT3 as the default filesystem for their native file structure, which is the next generation of the EXT2 filesystem. EXT3 is a tunable journaling filesystem; data migration between EXT2 and EXT3 is seamless and simple, with backwards and forwards capabilities. Red Hat Enterprise Linux 3 includes EXT3 updates for performance and stability, filesystem ACLs, and Logical Volume Manager.

As a result of the December 2003 acquisition of Sistina, Red Hat is now able to offer customers a clustered file system. Global File System (GFS) is a highly stable solution for enterprise and technical computing applications requiring reliable access to data. GFS allows multiple servers on a Storage Area Network (SAN) to have read and write access to a single file system on shared SAN devices, delivering the strength, safety, and simplicity demanded by enterprise and technical computing environments.

Performance

Red Hat Enterprise Linux is highly optimized to provide exceptional performance on Intel chip sets. Red Hat Enterprise Linux has been optimized for enterprise IT operations and is currently demonstrating world-class performance in critical environments. Anecdotal evidence from enterprise users suggests that Red Hat Enterprise Linux running on Intel chipsets are able to match, and in many cases exceed, the performance of Solaris 8 when running natively compiled C/C++ code. Additional optimizations in specific incidences have been able to achieve 5 to 20 times increases in performance over the application performance on UNIX. It is important to recognize that with the significantly cheaper Intel hardware it is likely that you will be able purchase a substantially faster and more well equipped Intel box than you would be able to get for the same money with a RISC hardware vendor, allowing a dramatic leap over RISC hardware in cost/performance. Such statements, however, are directed only at raw processing performance. In terms of I/O and network throughput, evidence suggests that the two architectures are closer to parity. Fiber-attached storage reads, for example, will not usually be noticeably faster on Linux than on UNIX. Again, this implicitly gives Linux a cost/performance edge because of the low hardware cost. In certain networking circumstances Linux is able to best UNIX performance, although more at the application level than in terms of raw TCP/IP or UDP throughput capabilities.

Red Hat Enterprise Linux 3 is achieving outstanding industry-standard benchmark results that can be used to assess capabilities across the entire product line. The results cover a range of configurations, architectures, and performance metrics. Red Hat Enterprise Linux has been a core part of configurations that offer significant performance and cost advantages over traditional RISC/UNIX environments.

The Transaction Processing Performance Council Benchmark C (TPC-C) has become a highly regarded industry reference that measures online transaction processing and database benchmarks. On December 9, 2003 Red Hat achieved the world-record TPC-C performance benchmark result. The audited figures were 1,184,893.38 tpmC at \$5.52/tpmC. This result beats the previous performance record achieved by Red Hat Enterprise Linux 2.1 by approximately 17%, and is the lowest \$/tpmC of the first ten performance results. The results of this benchmark demonstrate that Red Hat Enterprise Linux with Oracle in a clustered environment can be up to 50% faster than the best Windows 2003 result, and 98% faster than the best Solaris result.

The benchmark was achieved with Red Hat Enterprise Linux 3 running on a 16-node HP Integrity rx5670 Itanium cluster (each node being quad CPU with 48GB memory). The database was Oracle 10g with Real Application Clusters. The storage comprised over 2000 disks with a total capacity of 93TB. The application server tier comprised 80 dual CPU Xeon HP ProLiant DL360G3 systems. The total configuration cost was \$6.5M. This benchmark proves the outstanding performance, scalability, and cost effectiveness of Red Hat Enterprise Linux 3.

Other recently archived Red Hat Enterprise Linux performance benchmarks can be found here: <http://www.redhat.com/software/rhel/benchmarks/>

Stability

Red Hat Enterprise Linux has become quite well known for its stability over the past several years. Stories of machines locked in closets running for years are common, and most users rarely experience significant downtime. Much of this can be attributed to the robust architecture of the system itself. The Linux kernel is designed to minimize the effect that application components will have on each other and the kernel with regard to resource allocation. This means that if single applications fail, they will fail in isolation, and leave the rest of the operating system to function as expected. But how does a heavily loaded Red Hat Enterprise Linux system deployed in an enterprise datacenter environment hold up under the the toughest workloads? Research has shown that Red Hat Enterprise Linux holds up very well indeed, on par with, or better than results for RISC-based systems. The quality assurance measures Red Hat applies to the operating system prior to release include significant testing of high stress operational conditions, and we consider failures at this level to be unacceptable in a commercial production operating system.

Scalability

Linux has proven itself in enterprise environments and scalability has been a priority focal point for Red Hat engineering. While Red Hat Enterprise Linux 2.1 is a good solution for standard production environments, it demonstrated some limitations as a scalable enterprise solution. Red Hat has continued to improve scalability in Red Hat Enterprise Linux 3, which is twice as scalable as its predecessor.

There were two targeted areas for improvement with regard to scalability in Red Hat Enterprise Linux 2.1. The Max RAM count per process thread in Red Hat Enterprise Linux 2.1 is limited to 3GB and Max CPU count is certified to 8 (the theoretical limit is 32). Customers working with very large data sets with significant processing on single systems should keep these limitations in mind when deploying Red Hat Enterprise Linux 2.1. The low cost of additional Intel hardware means that it is easy to sidestep these issues and continue to grow Linux in data centers. If these limitations are of consequence for a customer, they should deploy Red Hat Enterprise Linux 3, which supports up to 64GB of memory. In addition to these enhancements, Red Hat Enterprise Linux 3 ships with a kernel based on 2.4.21 that includes many of the stable features from the 2.5 and 2.6 kernels. The 2.5/2.6 features that were backported include Ipv6, IPsec, Rmap VM, the 0(1) hyperthreading scheduler, per device locks for block IO, and the Native Posix Threading Library (NPTL).

The practical limits on Linux scalability have significantly improved and continue to evolve. Prior to the release of Red Hat Enterprise Linux, most Linux products were limited to x86 architectures, which inhibited Linux from taking off as a horizontal enterprise solution. Red Hat Enterprise Linux 3 is available for seven different architectures and can be deployed on anything from an administrator's laptop to a corporate mainframe. Red Hat's ISV partnerships and OEM relationships are very strong, with Red Hat Enterprise Linux giving customers the ability to build a completely Linux-based enterprise infrastructure.

As Red Hat increases its focus on large scale remote systems management, it is expected that the cost to add nodes in terms of administration will continue to diminish, allowing, in a theoretical sense, unlimited scalability. For those scenarios where single box scalability is required, Red Hat Enterprise Linux solutions built around IBM's S390 and Z Series systems are now becoming available. In addition, a whole new generation of datacenter-quality Intel Blade solutions from such companies as Egenera have also penetrated the market. These platforms deserve a much larger discussion than can be provided here and will continue to be an important component of the overall Linux market.

Security

The most secure platform Red Hat makes available is the Red Hat Enterprise Linux family of products. Red Hat Enterprise Linux has fewer serious security

vulnerability reports than either UNIX or Windows, despite the fact that Red Hat Enterprise Linux contains many applications not included in other operating systems. While this is not scientific proof of Linux security, it is a good indication of real-world experience for Linux. Red Hat Enterprise Linux gives the administrator complete control over network ports and services and many security and authentication applications are fully supported, including Kerberos, SSL, NIS, and PAM. Red Hat Enterprise Linux security errata are available to customers via Red Hat Network. Red Hat packages are signed with the Red Hat GNU Privacy Guard (GPG) keys so customers are certain errata updates are distributed securely from Red Hat.

Third-party firewall applications such as Checkpoint and monitoring solutions like BMC Patrol are supported and have proved very stable on Linux. Customers should note that security-related products available from ISVs are only certified for Red Hat Enterprise Linux line of products. Security applications modified to run on the Red Hat Linux or Fedora code bases are not supported by Red Hat or the application vendor.

Red Hat Enterprise Linux, unlike Red Hat Linux or Fedora, has achieved the US Defense Information Systems Agency (DISA), Common Operating Environment certification. The COE certification means that Red Hat Enterprise Linux is approved for deployment at the US Department of Defense and has passed this agency's strict requirements for interoperability, performance, and standards compliance, a true testament to the federal governments confidence in Red Hat Enterprise Linux as a sound solution. Customers interested in learning more about the COE certification should refer to the the Red Hat Enterprise Linux COE whitepaper online at:

https://www.redhat.com/apps/webform.html?event_type=whitepaper&eid=100

In addition to the applications , management tools, and certifications associated with providing security on Linux, it is important to understand the role of the open source development model in making Red Hat Enterprise Linux secure. Open source means that all of the code that Red Hat runs has been through a large amount of peer review. Open source development also means that new bugs are resolved accurately and made available in a timely manner with documentation for the next round of peer review or future development.

Red Hat Enterprise Linux customers with an interest in tuning their systems securely should refer to the Red Hat Enterprise Linux Security Guide online at: <http://www.redhat.com/docs/manuals/enterprise/RHEL-3-Manual/security-guide/>

Security enhancements for the Red Hat Enterprise Linux 3 product line include filesystem Access Control Lists, a general-purpose cryptographic API in the kernel and kernel support for ipsec on IPV4.

Red Hat has plans to eventually integrate Security Enhanced Linux, based on

the 2.6 kernel, into its future enterprise offerings. The latest beta from Fedora project includes SE Linux. When Red Hat gathers feedback from the community on Fedora test2, and the default SE Linux security policy incorporated into it, the favorable features will be incorporated into RHEL 4.0 which is scheduled for release in early 2005.

Enterprise operating environment

Those who were involved in the IT industry as Sun and Microsoft became the dominant players in their respective markets will recall what a difficult transition it was to integrate and support those new platforms. Recognizing that the barrier to entry for Linux migrations can be high, Red Hat has worked to make the process as painless as possible. Below you will find information on the common tasks that Red Hat Enterprise Linux is being used for and on how enterprise clients are able to integrate Linux into their environments without having to discard their existing infrastructure and knowledge.

Typical Linux Usages

Although Linux is a very flexible operating system that is being used everywhere from embedded devices to mainframes, the majority of enterprise users are deploying Red Hat Enterprise Linux on Intel x86 machines in one of three primary configurations: IT infrastructure and interdepartmental servers, application servers for core business components, or as a desktop/workstation solution. Red Hat has also established itself as a major player in the datacenter for database connectivity and in numerous other areas, such as CAD development and graphics design, but these can be fairly specialized solutions. We will focus on the more general deployment scenarios here.

IT Infrastructure

Red Hat Enterprise Linux has largely made its name in such applications as customer-facing e-business operations, internal routing, firewalls, file serving, print serving, interdepartmental databases, and dozens of other standard IT infrastructure functions. Here's a quick look at the specific solutions that are commonly seen; additional information can be found at the end of the document:

Table 1: IT Infrastructure

Function	Software Components	Details
Web server	Apache, TUX	Apache is the world's number one Web server. Linux offers a full suite of Web hosting, application hosting, and proxy capabilities. TUX is a threaded Linux Web server for high performance Web serving.
Routing/DNS	BIND8/9	Full routing capabilities are supported.
File server	NFS, openAFS, GFS, NDS, openLDAP, SAMBA	Another core area for Red Hat Enterprise Linux; consistent communication with all platform types is one of Red Hat's primary goals.
Firewall	Iptables	Iptables is included free.
NIS server	NIS	Simple network lookup service that provides information to all machines on a network.
Database server	Postgres, MySQL	Postgres and MySQL are very robust open source databases.
Mail server	Sendmail, Postfix	Sendmail is the most widely used MTA on the Internet. Postfix is a fast. Secure open source MTA alternative to Sendmail.
Source repository	CVS	CVS offers a free and widely used repository.
Web caching	Squid	Squid is a Web proxy server that ships with Red Hat Enterprise Linux.

For business applications designed to run on UNIX, the port to Red Hat Enterprise Linux is relatively simple. This includes C/C++ applications, Java applications, scripts, and several other legacy or newer languages. Linux was originally conceived of as a server operating system and it has been configured to work optimally in that environment. Performance has proved to be comparable to or better than that of UNIX, and scalability and reliability are more than acceptable again, saving money by switching to Intel hardware is an easy choice. Additional information on porting applications to Linux is given in Section 4 of this document.

Desktop

Traditionally UNIX has not played a major role in the end-user desktop space. It has been limited to specialized usage within an enterprise for the running of specific business applications, application development, or as a powerful workstation environment. Red Hat Enterprise Linux can act very effectively in all of these environments, and in many companies is being customized to act as a

replacement for existing Windows desktop clients. Linux uses the XFree86 X-Windows environment as its graphical interface, with various desktop environments available to provide a consistent user interface and all of the baseline tools a desktop OS user expects. Additionally, there are a number of office productivity suites, web browsers, graphical manipulation, and personal productivity applications available. There are also a number of ISV management tools, such as Oracle Enterprise Manager that can now be run from Linux. This table illustrates some of the application availability. Note that information on Linux as a development environment is given in detail in Section 4 rather than here:

Table 2: Desktop Availability

Function	Software Components	Details
Desktop environment	GNOME, KDE, Bluecurve	Bluecurve is the default desktop in Red Hat Enterprise Linux 3. Gnome is the default desktop in Red Hat Enterprise Linux 2.1. Each desktop provides all of the basic functions Windows users would expect from a base desktop installation, including file browsing, desktop configuration tools, basic text editors, calculator, etc. Sun has chosen Gnome as their next-generation desktop.
Web browser	Mozilla, Konqueror, Galeon	All are free and open source.
Office suites	OpenOffice.org, Koffice, StarOffice	OpenOffice.org is a leading commercial office suite for Linux. It includes word processing, spreadsheet, graphical development, slide presentation, and web page development tools. All three support Microsoft filetypes.
Messaging clients	Ximian Evolution, Mozilla, text readers	Traditional UNIX mail readers are available.

The Red Hat Enterprise Linux 3 desktop enhancements include:

- XFree86 4.3.0
- Bluecurve graphical user interface (Unified GNOME/KDE look and feel)
- OpenOffice.org 1.0.2 office productivity suite
- Ximian Evolution 1.4.3
- Mozilla 1.4

ISV Application Support

One of the biggest challenges Linux has faced moving into the enterprise has been the support of Independent Software Vendors. Nearly all vendors have been working on some form of release for Red Hat Enterprise Linux. Companies like Oracle, BEA, VERITAS, IBM, and SAP view Linux as strategically important to their future success. Red Hat has been working with these vendors to ensure that they're fully integrated with Linux and to help them get to market faster. For a comprehensive catalog of certified applications for Red Hat Enterprise Linux, visit: <http://www.redhat.com/apps/ISV-catalog>

If you require an application not listed, contact the vendor or Red Hat to check on its availability. One of the major advantages of selecting Red Hat over other Linux vendors is that we will work with a vendor to get their applications to market if there is a customer need.

Large-scale Linux deployment

Large enterprises working with UNIX have often invested a tremendous amount into developing a global deployment strategy. This may include an automated build and install solution, a set of ISV management software components, system administrator training and skills development, and documentation of the entire process. Although there will certainly be costs associated with adding Linux to such an environment, Red Hat has developed the knowledge and tools to make it as painless and quick as possible. The primary goal in such a scenario is to provide a Linux deployment methodology that allows enterprises to leverage existing infrastructure investments and in-house administration and development skills. This begins with the deployment technologies; UNIX systems are often deployed using the bootp protocol. Intel fully supports remote boot and install functionality with bootp and PXE. All that is required is to make sure the ethernet cards have the PXE-capable onboard eeprom. Red Hat provides a tftp boot server in the distribution that can perform the installations. If organizations have a web page or custom interface to configure the install process on a per-system or subnet basis, there are tools available on Linux for that as well. For those using system imaging tools rather than relying on the actual native installation tools, it may be possible to use the same tools for Red Hat Enterprise Linux, or there are alternatives available. Regardless of the specific technology, the goal is to be able to invest in some development work upfront to construct a system that works just like the existing UNIX build system to those installing the nodes. This allows the Linux migration to occur with minimal new investment in skills development. Beyond the base OS there is generally a set of ISV applications used to manage the installed systems, as well as a set of core applications needed to add functionality to the environment. As mentioned earlier, Red Hat has been working to ensure such a software stack is fully available on Linux. To the extent that it is currently available, you are able to simply drop Linux systems into your existing infrastructure without changing any of the management components. Here is a quick look at some of the management tools and operational applications that are available.

Table 3: Deployment

Function	Software Component
Asset tracking	Tangram Asset Insight, Red Hat Network, Tivoli, Computer Associates UniCenter
System monitoring	RHN Monitoring Module, BMC Patrol, Tivoli, CA UniCenter, HP Openview
Event monitoring	RHN Monitoring Module, Trend SNMP
Backup	Amanda, Legato, VERITAS Net Backup, BRU, CA UniCenter
Job Scheduling	CA Unicenter AutoSys Job Management, ControlM
Storage Connectivity	VERITAS Foundation Suite
Filesystems and Logical Volume Manager	VERITAS FS (VxFS), VERITAS VM (VxVM), GFS
Software Packaging	RPM
Clustering	Cluster Manager, Oracle 9iRAC, VERITAS Cluster Server, Legato, PowerPath v3.0.2 b069, GFS
Database	Oracle, PostgreSQL, MySQL, Sybase, DB2

Remote management capabilities

Once Linux is deployed, it is typical to support it from a centralized management location. The software components just outlined are a part of that support. In addition, the standard range of UNIX remote administration tools are available under Linux such as telnet, FTP, SSH, scp, and rsh. Although these services will need to be selected within the bounds of your security policy, they are invaluable tools in managing deployed Linux systems and will likely continue to be integral to the support procedure in many enterprise situations.

Skills transfer and training

As a result of the close kinship UNIX and Red Hat Enterprise Linux enjoy in terms of command line instructions, administration tools, development tools, and the overall operating environment, the investment required to train existing development and administration staff is usually fairly low. The skills migration for UNIX administrators and developers to Red Hat Enterprise Linux is much more direct than a similar migration to Windows. Red Hat's comprehensive skills development and certification curriculum (such as the RHCE program) provides IT management with a complete program for skills transfer when migrating from UNIX to Red Hat Enterprise Linux. Additional information on Red Hat's training and certification programs can be found in the section of this paper entitled Support Solutions for Linux in the Enterprise, and at www.redhat.com/training.

Directory and authentication services

Linux has been running in security and file serving capacities for quite some time and is very capable of integrating into the types of infrastructures currently in use in UNIX production environments. Kerberos, NIS/NIS+, PAM, NFS, openAFS, LDAP, Oracle Internet Directory, Open LDAP, SAMBA, and many other authentication or directory related services are fully supported.

Proprietary application porting and development

There are three primary types of applications Red Hat is typically engaged to help enterprise customers migrate to Linux: native C/C++ code, Java code, and scripts. The level of complexity of doing such a migration from UNIX to Linux is not very high relative to a UNIX to Windows port. This section provides more detail on the specifics of migrating applications to Linux.

A word about the GPL

One of the things that confuses enterprise clients most about moving to Linux is the GNU General Public License, which has been characterized by many as a viral license . This sinister moniker simply means that there are certain conditions that require that the license be extended to restrict the behavior of those developing code that utilizes the components of the licensed software. Nearly all strict software licensing schemes are viral, including those used by Solaris and Windows. In the case of the GNU General Public License, that condition exists only when you link your code against code developed under the GPL. However, the C/C++ libraries and most of the other libraries and toolkits available on Linux are developed under the LGPL, or Lesser GPL. This license allows dynamic linking of these components, meaning proprietary development is perfectly feasible on Linux. A good example of an application that has been built to run on Linux without needing to become open source under the GPL is Oracle. Nearly all ISV applications are proof that the GPL and LGPL, though restrictive in rare cases, do not realistically prevent organizations from porting their applications to Linux and continuing to be the sole copyright and license holder of those applications. Red Hat has helped hundreds of companies port closed source applications to Red Hat Enterprise Linux through our services and is able to fully inform customers of any GPL-related issues as they arise.

The Linux development environment: C and C++

The development environment most UNIX developers have come to expect is largely available under Linux as well. Let's look at the C/C++ environment first, as that is where the majority of porting work occurs. The fundamental framework for this environment are the tools used to build C/C++ code; the C libraries, compilers, build utilities, and debuggers. This is a quick list of those tools as they exist for Linux:

Table 4: Development

Function	Software Components	Details
C/C++ libraries C/C++ compiler GCJ	glibc 2.2, glibc 2.3.2 gcc 2.96, gcc 3.2	Fully ANSI-compliant libraries and compilers. Red Hat Enterprise Linux 3 ships with glibc 2.3 and gcc 3.2. GCJ is a java compiler.
Build utilities	Linker, make, Eclipse	Linker is a category indexing program . Make is a compilation tool. Eclipse is an IDE tool platform.
Debuggers	gdb, ddd	gdb is the default debugger; several ddd graphical or otherwise enhanced versions of gdb have been developed such as ddd.

There are a couple of detailed points that should be made about development for Linux. First, in general, Red Hat strives to achieve backward compatibility for all compiled programs. This is ABI compatibility. Unfortunately, this is not always maintained as the compilers and C libraries progress, so it is important to understand which versions of the compiler and C libraries are acceptable to use for specific targets. For each release of Red Hat Enterprise Linux, the ABI will be stable as updates are released for the lifespan of the product. Threading support in Red Hat Enterprise Linux 2.1 is not as robust as some UNIX platforms. Although threading is well supported and applications will compile and run, there historically some aspects of threading and some scaling situations where it fell short of competitors. Red Hat made the resolution of these issues a top priority and has significantly enhanced threading in Red Hat Enterprise Linux 3 by integrating the Native Posix Threading Library (NPTL). For more information on NPTL please see:

http://www.redhat.com/partners/pdf/POSIX_Linux_Threading.pdf

Beyond support for the standard development tool chain, Red Hat can provide Enterprise Tools Support for the GNUPro compiler and tool chain. GNUPro is Red Hat's commercial version of the gcc compiler and tool chain that can be customized and maintained for your environment.

Technical features in the Red Hat Enterprise Linux 3 development environment include:

- gcc 3.2.3 tool chain
- gcc "ssa" tool chain included as a technology preview
- gcj / libgcj (Java gcc compiler front-end)
- gdb 5.3.90 - including multi-threaded core dump and gcore
- glibc 2.3.2

Third-party libraries

There are a number of open source third-party C/C++ libraries available for Linux for performing a range of operations from security to mathematical functions. Commercial libraries, such as many of RogueWave's libraries, are available as well. This can be fairly detailed information; please check with Red Hat for more information on specific needs. The libraries for graphical development for Gnome and KDE are both included with Red Hat Enterprise Linux. Although very few standard UNIX applications have many graphical components, this can be appealing if you are migrating applications from Windows (although moving from the MSFC can be a bit time consuming).

Red Hat Developer Suite

Red Hat Developer Suite is a member of the Red Hat Applications product family. Red Hat created the Developer Suite to simplify the migration of developer skills and applications to Red Hat Enterprise Linux. It provides a fully featured Integrated Development Environment (IDE) based on the open source Eclipse project for application developers. Eclipse is an open extensible IDE that provides real value because of the tool plug-ins. The tool plugins give the platform the ability to work with many formats including java files, Web content, graphics, video, etc. Eclipse additionally gives the developer the ability to independently develop tools that can be easily integrated with other tools or applications. For more information on the Red Hat Developer Suite, please visit <http://www.redhat.com/software/rha/developer/>

Specialized porting tools

In some cases customers have wanted to develop specialized porting library sets for their environments to facilitate rapid migration. Red Hat has tremendous compiler and library experience and is able to help facilitate the development of such tools. For more information, visit www.redhat.com/products/tools/gnupro/subscriptions.html.

Java and scripting languages

After C and C++ applications, the most common ports to Red Hat Enterprise Linux are Java applications. This is a very simple port, as Red Hat currently supports versions of Java through 1.3. Also, middleware servers such as Oracle Application Server, BEA Weblogic and development tools, such as Oracle Developer Suite and JDeveloper are fully supported on Linux, meaning it is very easy to bring Java applications developed for use on those platforms over just as quickly. Scripting languages, such as Perl, Bash, awk, sed, et al. are also a fairly easy port; the real challenge is that the scripts themselves are usually referring to objects, files, or devices that are named something slightly different in Linux. Global search and replace is capable of resolving some of these, but often these types of applications need a lot more attention for a thorough port. In some cases, simply starting over is the best idea.

Software packaging

Like some UNIX platforms, Linux supports the concept of software packages. In the case of Red Hat Enterprise Linux, the facility that supports this is called the Red Hat Package Manager, or RPM. Much like Solaris packages, these are simply CPIO archives wrapped up with some associated installation and uninstallation scripts. The development of RPM packages can range from fairly simple to fairly complex depending on the nature of the application being installed. The infrastructure Red Hat Enterprise Linux uses as an operating system is heavily built on RPMs, and much of our future support infrastructure will rely on RPM as a delivery and management component. As such, we strongly encourage clients to use RPM as the install method for their applications. As with Solaris packages, there are definite ongoing support and manageability benefits to doing so.

Supporting Linux in the enterprise

One of the biggest concerns for IT managers considering Red Hat Enterprise Linux for their enterprise is ensuring comprehensive vendor support for globally deployed systems. In this context, vendor support encompasses the responsibility for the functionality of the operating system as well as for migration, deployment, and ongoing usage. Red Hat's business model is built around the delivery of end-to-end services for all stages of the solution life cycle, from consulting (assessment, benchmarking, planning) through development and on to systems and management.

Red Hat Enterprise Linux Global Support Services

Red Hat Global Support Services (GSS) provides telephone and Web-based technical support for Red Hat Enterprise Linux customers. All GSS services are available as annual subscriptions only. There are three levels of Production GSS services available for the Red Hat Enterprise Linux product line. Basic subscriptions mostly address installation and hardware configuration issues during standard business hours. Standard subscriptions address everything associated with the Basic subscription in addition to typical service configuration issues frequently used in production environments during standard business hours. Premium subscriptions are the highest level of GSS services available and include 24x7 support. For detailed information on the types of subscriptions available please see:

http://www.redhat.com/support/techsupport/production/RHEL_main.html

Support for Red Hat Enterprise Linux is available for the base operating system and the services and packages outlined in the corresponding Service Level Agreement for the subscription the customer purchases. Each annual subscription for Red Hat Enterprise Linux products has a specific SLA. For more information on Red Hat GSS Service Level Agreements please see:

<http://www.redhat.com/support/sla>

Red Hat Enterprise Linux Annual Support subscriptions are intended to support individual systems and system administrators who are managing production systems. Red Hat has worldwide call centers open 24x7, and staffed in seven native languages to ensure Linux users are fully supported. This level of support ranges from basic installation and usage questions to complex Level 2 configuration and usage issues. Level 3 support, including bug fixes, workarounds and security fixes, are included under these annual Service Level Agreements as well.

Global Support Services Technical Account Manager

Red Hat GSS Technical Account Managers provide a consistent support interface between organizations while building a productive, proactive service partnership. The TAM is a highly skilled engineer assigned to provide technical account management and to assure your technical issues are dealt with quickly and effectively, ensuring the highest levels of performance on your Service Level Agreement. The TAM also acts as your champion within Red Hat Engineering, providing visibility to the technical roadmap and ensuring that your priorities and requirements for Red Hat Enterprise Linux are considered during the release cycle. For more information, visit:

<http://www.redhat.com/support/service/offerings/technical.html>

Red Hat GPS Services

Red Hat Consulting Services provides consulting resources and expertise to assist in Linux planning, development, or deployment on-site. Services are intended for customers requiring technical assistance beyond the Service Level Agreements associated with GSS services. Services range from readiness assessment, infrastructure planning, and benchmarking to system administration, development work, and installation and deployment assistance, all the way through staff augmentation. Our consultants offer multiplatform skills and expertise, acknowledging that most enterprise IT environments are heterogeneous.

GNUPro enterprise tool support

Bundled with Red Hat's GNUPro Toolkit is Red Hat's annual compiler and toolchain support for engineering development teams. This support ensures an ongoing link to the maintainers and drivers of the GNU software via updates on the latest versions of GNUPro Toolkit, access to the Red Hat Web-based support portal, and patch-level bug fixes. For more information, visit <http://www.redhat.com/services/tools/embedded/gnupro>

Red Hat Global Learning Services

Red Hat offers training and skills development ranging from introductory courses to advanced system administration and development. The Red Hat Certified Engineer (RHCE) program is the most widely accepted Linux training standard, and is available in training facilities worldwide. The Red Hat Certified Technical

Engineer (RHCT) is an ideal technician-level credential for persons supporting Linux systems throughout an organization. RHCT is a good choice for those transitioning to Linux from non-UNIX OSes, or who want to prove their competencies at a midway point on the way to RHCE, one of the ten hottest certifications in the IT industry. Training can be delivered in Red Hat training centers, on-site through our mobile classroom, or for certain curriculum, through distance learning online. Customized training courses can be developed around specific requirements and delivered through any of these methods. For more information visit: <http://www.redhat.com/training>

Red Hat Network

Red Hat is committed to reducing the overall cost to administer Linux systems in the enterprise. To do this we have developed several solutions that enable delivery and management of Red Hat software and systems as part of an overall service subscription. Rather than having to manage each instance and application on your Linux system, you can use a single integrated Web interface to manage the complexity of installation on hundreds or thousands of machines. The backend for this work can be hosted and managed entirely by Red Hat, further reducing overhead.

Customers that wish to manage and maintain their own custom packages have the option of electing the on-site Proxy or Satellite Red Hat Network architectures. With the Proxy solution, the customer's individual systems connect to a local RHN Proxy that sits behind the customer firewall. The Proxy aggregates all necessary data in cache and communicates via a dedicated SSL connection with the RHN servers at Red Hat. All information stored in the RHN database is kept on the RHN servers. ISV and internal customer applications can be packaged as RPMs and administered to client systems via custom channels.

The Satellite architecture differs from the Proxy in that all RHN functionality is on the customer premise, allowing the customer greater functionality and customization. The Satellite server does not require a dedicated SSL connection to the RHN servers at Red Hat. Errata and updates are stored in an embedded Oracle database that is part of the Satellite model. The Satellite solution allows customers to take their RHN solution completely off-line if desired. The Satellite also offers customers more sophisticated management tools, channel permissions, errata cloning, the ability to do PXE boot provisioning, and configuration file customization for specific systems sets.

In addition to the architectural variations of RHN, Red Hat offers customers a module choice. The Update module is included with all Red Hat Enterprise Linux subscriptions and includes errata updates via RHN for individual clients. The Management module allows the customer to group and manage many systems via a central web interface. With the RHN Provisioning module, the system is able to replace kickstart image installation, rollback RPMs to return systems to

their previous state, distribute configuration files to groups of systems, etc. In the future, RHN will incorporate much of the functionality of asset tracking software, event and monitoring software, and other remote administration tools. This is an area of strategic investment for Red Hat, and the services, with over 1.2 million registered client nodes, are already proving invaluable to many of our largest customers.

For complete information on Red Hat Network offerings please see <http://www.redhat.com/software/rhn/>

Migration strategies

Suggested migration plans and timelines

Red Hat Enterprise Linux has proven to be an effective replacement for low to mid-range UNIX/RISC systems. Clients may choose to develop a horizontal Linux support strategy before deploying any Linux or may take a vertical snapshot to prove that Linux can work in selected environments and gradually let the infrastructure evolve. Something in the middle is typical, as organizations need to prove that Linux is an effective solution for their environment before they can develop the entire infrastructure to support it.

The following is a high-level outline of a migration plan Red Hat deployed for Fortune 100 customers, which we believe is a fairly realistic path. This is intended to provide a cursory overview and some general guidance for consideration. These project threads may be completed concurrently, reducing the overall time to market. Additionally, selected applications may be rolled out almost immediately while work on the larger initiative continues. This allows the cost benefits to be realized now and not just at the final deployment.

Phase 1 Pilot Project 3 Months

Key Goals:

- " Determine status of required, third-party ISV applications
- " Perform baseline OS benchmark comparisons for performance and functionality
- " Develop initial pass of a customized installation
- " Begin documentation on an overall Linux deployment methodology
- " Begin development of technologies central to the widespread deployment of Linux
- " Port and test an initial internal application
- " Begin determining which infrastructure components can quickly be switched over to Linux
- " Begin determining which proprietary applications can effectively be migrated to Linux
- " Test Linux as a component of the existing UNIX infrastructure

- " Gain general working skills with Linux
- " Develop overall cost model for the move to Linux

Phase 2 Rollout Preparation 3 Months Key

Goals:

- " Finish construction of deployment technology
- " Build out infrastructure needed to deploy Linux worldwide
- " Finalize the customized install of Linux, including ISV components
- " Produce end-user documentation
- " Perform final deploy system QA
- " Begin widespread application porting
- " Begin rollout of infrastructure replacement components
- " Begin training of system administrators or developers

Phase 3 Production 3 Month ramp-up, then ongoing

- " Begin worldwide rollout
- " Produce second cut of customized install with bug fixes
- " Continue to port and develop new applications for Linux

ISV application support

To date, there are over 750 ISV applications that run on Red Hat Enterprise Linux. The Red Hat Enterprise Linux Application List is a list of Red Hat Certified and Red Hat Ready applications that are supported on Red Hat Enterprise Linux. Customers deploying these applications have the assurance that the software has been tested on Red Hat Enterprise Linux and is compliant with Red Hat's guidelines for interoperability. Red Hat Certified means that Red Hat and the application vendor have a partnership in place by which joint customers can be supported. Red Hat Certified Applications are reserved for Red Hat's Premier Software Partners. Red Hat Ready applications have been tested by the application vendor on Red Hat Enterprise Linux, and the vendor has agreed to comply with the Red Hat Ready Guidelines. Red Hat will use best efforts to support customers using these products.

This table gives a quick view into what ISV applications are certified on Red Hat Enterprise Linux 2.1:

Table 5: ISV Preview

ISV	Supported Applications
BEA	BEA WebLogic 7.0 SP1 and SP2, BEA WebLogic 6.1 SP4 and SP5, BEA WebLogic Platform 7.0, SP1, SP2, BEA WebLogic JRockit 7.0 J2SE 1.3.1, BEA WebLogic JRockit 8.1 J2SE 1.4.1, BEA Tuxedo 8.1, Various BEA WebLogic Adapters for WebLogic Integration
BMC	Patrol for MS - Perceive Web Server 7.1.01, Patrol for MS Perform 7.1.01, Patrol for MS - Predict 7.1.01, Patrol for Unix 9.0.00, Patrol for Unix Perceive Managed Nodes 7.1.01, Patrol for Unix - Perceive Web Server 7.1.01, Patrol for Unix Perform 7.1.01, Patrol for Unix - Predict 7.1.01
IBM	DB2 Universal Database Enterprise Server Edition 8.1, Informix Dynamic Server Enterprise Edition 9.4, Rational ClearCase 5.0, Tivoli Enterprise Console 3.8, Tivoli Storage Manager 5.2, WebSphere Application Server 5.0, WebSphere Application Server Enterprise 5.0, Numerous other IBM Applications
Oracle	Oracle9i Server Enterprise Edition, Oracle9i Server Standard Edition, Oracle9i RAC, Oracle 8i Server, Oracle Express Server with 8.1.7, Oracle9i Application Server Enterprise Edition with 8i or 9i Server, Oracle11i eBusiness Suite, Oracle Collaboration Suite with Oracle Server Enterprise Edition 9i
Rogue Wave	Rogue Wave Application Tuning System, Rogue Wave Lightweight Enterprise Integration Framework, Rogue Wave XML Object Link, Source Pro C++ Core, Source Pro C++ Net, Source Pro C++ Analysis, Source Pro C++ DB
Sybase	Adaptive Server Enterprise (ASE) 12.5.0.3, Replication Server (RS) 12.5, Planned: Adaptive Server Enterprise (ASE) 12.5.1 (32, 64), Planned: Replication Server 12.6, Planned: Open Client/Server 12.5
Synopsis	U-Foundation 2003.03, 2003.06, 2003.09
VERITAS	VERITAS Cluster Server, VERITAS Foundation Suite, VERITAS NetBackup Business Server, VERITAS NetBackup Datacenter

Note: The information in the above table is subject to frequent change. For complete and current of ISV application support for Red Hat Enterprise Linux, visit our website at <http://www.redhat.com/apps/isv-catalog>

Conclusion

Red Hat Enterprise Linux has made substantial leaps in scalability, functionality, and enterprise supportability in the last year. The past twelve months have yielded critical improvements in key aspects of Linux, including enhanced SMP support, file size support, filesystem size support, ISV support, and general scalability. With the release of the 2.6 kernel, and the expansion of Red Hat's global technical services capabilities to help enterprises navigate the challenges

of migration, Linux is well-positioned as a compelling alternative to expensive, proprietary RISC/UNIX solutions from Sun and other vendors. Through ongoing customer feedback and increased enterprise deployment, Linux will continue to improve rapidly in processor scalability, performance, and functionality through the availability of mission-critical enterprise applications. Many of our clients simply want an alternative to proprietary UNIX, while some actively fear that specific flavors of UNIX are becoming marginalized in the consolidation of UNIX and they want a future migration path. Whatever the reasons for considering a migration, once our customers have begun to use Linux, they have not looked back. If you'd like more information about Red Hat, be sure to visit <http://www.redhat.com>, or call us at 1-888-REDHAT1.

WANT MORE INFORMATION?

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