



Migrating to Red Hat Enterprise Linux - Benefits and Guidelines

Abstract

This white paper describes the features and benefits of the Red Hat Enterprise Linux product family. It briefly outlines factors that need to be considered when planning a migration from a consumer Red Hat Linux release, such as 8.0 or 7.1, to an Red Hat Enterprise Linux family product. It also discusses some of the issues associated with migrating applications from proprietary Unix, Microsoft Windows, and other Red Hat operating system environments.

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Introduction

The Red Hat Enterprise Linux product family, released in several phases starting in May 2002, provides enterprise-class features that enable Linux-based solutions to be deployed across the widest range of enterprise IT environments. With a potent combination of technical features, certified ISV applications, and portfolio of services, Red Hat Enterprise Linux products are the world's leading Linux-based enterprise operating system solutions.

The second full release of the Red Hat Enterprise Linux family, version 3, was delivered in October 2003 and introduced many significant enhancements to the product set.

Meanwhile, Red Hat's traditional consumer-focused products – Red Hat Linux Personal and Red Hat Linux Professional, versions 7.x, 8 and 9 – which were historically used by small commercial environments and open source community developers, are reaching the end of their support lifetime. For the future Red Hat will support these two very different markets with separate offerings. For the open source community the new Red Hat Fedora project will provide leading edge technology and rapid development cycles, while Red Hat Enterprise Linux products will meet the needs of the retail/commercial market.

As a result of these changes, many users of Red Hat's traditional consumer products will be faced with the prospect of upgrading their existing systems to Red Hat Enterprise Linux products. This white paper outlines the benefits of Red Hat Enterprise Linux solutions for commercial application environments, and shows that a properly planned and managed upgrade will be straightforward for the majority of existing Red Hat Linux customers.

What is Red Hat Enterprise Linux?

The Red Hat Enterprise Linux product family is a suite of powerful enterprise operating system solutions that are designed for commercial and mission critical applications. Currently, the family of products comprises:

- Red Hat Enterprise Linux AS. This is the high-end server product, suitable for large departmental and corporate server deployments.
- Red Hat Enterprise Linux ES. This is the entry-level and mid-range server product, suitable for most small system and departmental deployments.
- Red Hat Enterprise Linux WS. This is the high-end desktop partner to the server products. It is suitable for personal productivity and technical/commercial workstation applications.
- Red Hat Desktop. This is the general purpose desktop product, suitable for single-purpose and personal productivity applications.

Red Hat continuously enhances the Enterprise Linux family, working to provide a high-value open source operating system environment that delivers all the capabilities traditionally associated with proprietary operating systems. The following points outline the major technical and non-technical features of the family:

- Performance/Scalability

All current Red Hat Enterprise Linux, v. 3, products are based on Linux Kernel 2.4.21, enhanced with numerous features backported from the Linux 2.6 kernel that have been hardened for use in commercial systems. New features include:

- Native POSIX Thread Library – this Red Hat-designed implementation provides a fully POSIX-compliant multi-threading API. Performance is several orders of magnitude higher than previous multi-threading implementations, making it practical to deploy heavily multi-threaded applications (such as Java applications) in a Linux environment.
- Increased SMP scalability – the SMP subsystem has been enhanced to support up to 16 logical processors, twice the number supported in v. 2.1.
- SMP Scheduler enhancements – the scheduler has also been enhanced to support hyperthreaded CPUs intelligently. This work follows on from scheduler enhancements implemented in version 2.1.
- Bounce Buffer Elimination - this feature, which eliminates I/O buffer copy operations, was originally provided in version 2.1 for systems with 1-4GB of main memory. In version 3, it has been enhanced to support direct I/O capabilities for systems with more than 4GB of memory.
- 4GB-4GB virtual memory split – this feature, developed for X86 systems, increases the virtual address space of the kernel from 1GB to 4GB and of every user process from 3GB to almost 4GB (3.7GB). The increased kernel address space allows the kernel to manage much larger physical

memories, so version 3 supports up to 64GB of physical memory (4 times the memory supported by version 2.1). The increased user process virtual address space allows applications to consume more memory, with consequent performance improvement.

These and other performance enhancements make Red Hat Enterprise Linux products the most suitable Linux solutions for server and desktop/workstation systems running commercial/enterprise applications. Leveraging these features has enabled Red Hat Enterprise Linux products to deliver excellent benchmark performance for TPC-C, TPC-R, SPECjAppServer2001, and Ecpref.

- Reliability

To ensure that Red Hat Enterprise Linux software components are of the highest quality, Red Hat Engineering subjects them to the most stringent qualification and testing over an extended period of time. The products are delivered on a 12-18 month schedule; this provides the opportunity to impose a much more rigorous development environment than was practical with the traditional Red Hat Linux products, which typically had a 4-6 month development, testing and delivery cycle. Red Hat Enterprise Linux undergoes twelve months of development followed by six months of testing, much of it performed jointly with hardware and software partners.

- Services

A primary goal of the Red Hat Enterprise Linux family is to ensure that deployments are as successful as possible. Consequently the provision of a world-class service infrastructure is a vital component of the products. All Red Hat Enterprise Linux products are available with a full year of services, with support for unlimited incidents. Several service plans are available, scaling up to 24x7 coverage with 1 hour response. Additionally, Red Hat will provide support for Red Hat Enterprise Linux releases for 5 years, making long term deployments a practical proposition.

Included as a core component of all service plans is access to Red Hat Network, Red Hat's Internet-based system management capability. Red Hat Network (RHN) simplifies system administration by detecting when security and software errata are required, and then automating system updates. Optional features, such as RHN Management, allow customers to deploy large-scale RHN configurations, monitoring and managing thousands of systems and custom applications.

In summary, Red Hat Enterprise Linux products provide a fully-featured, enterprise-strength operating system solution that is capable of meeting the demands of the most rigorous commercial environment. Its functionality, performance, scalability, and reliability, combined with comprehensive services, make it a far more effective platform for commercial deployments than Red Hat's 7.x, 8 & 9 consumer products.

Application Availability

Independent software vendors (ISVs) have been quick to appreciate the benefits of Red Hat Enterprise Linux solutions. Providing support for their applications on these products offers numerous advantages:

- The extended release cycle simplifies application delivery, sales and support.
- The extended release cycle means that applications from multiple vendors will all be supported on the same platform at the same time (a situation that rarely occurred with the traditional consumer products).
- Technical features deliver performance and scaling to match or exceed proprietary Unix and Microsoft Windows solutions.

Since the initial availability of Red Hat Enterprise Linux products, Red Hat has been working with a wide range of ISVs to ensure that customers can choose from a rich application portfolio. Because all products in the family are based on a common core, ISV application certification on one family member automatically accrues to other family members. The number of ISVs who are providing their applications on the Red Hat Enterprise Linux family is growing rapidly.

Refer to <http://www.redhat.com> for the latest list of ISV partners. Red Hat's ISV partners include:



Benchmarks

For many IT organizations the availability of Industry-standard, audited benchmarks is an important component in the purchase decision process. Red Hat Enterprise Linux has achieved world record results for TPC-C using Oracle 9i RAC and ECperf using Oracle 9i AS. These benchmark results are documented at their associated web sites and in other Red Hat white papers.

In September 2003, Hewlett Packard announced a world record 4-processor TPC-C benchmark achieved with Red Hat Enterprise Linux AS, version 3, and Oracle 10g Standard Edition Database running on a single 96GB, HP rx5670 Itanium system. The database was deployed on 356 disk drives that provided 6.8TB of storage. The TPC/C results were 136,110 tpmC @ \$3.94/tpmC. For the application server tier, 10 x HP DL360G3 systems (each dual CPU, with 4GB main memory) running BEA Tuxedo 8.1 were used.

Two other benchmarks were run on the same machine and make an interesting comparison. The first was with Windows/SQL Server, achieving 121,065 tpmC at \$4.79, the other with HP UX/Oracle, achieving 131,639 at \$7.25. Note that the Red Hat Enterprise Linux 3 result is better than both of these in terms of performance and price/performance. At the time of publishing this was the best 4 processor performance number and it also beat several published 8 processor results.

In December 2003, Red Hat, Oracle and HP announced the overall performance world record result for TPC/C, based on a 16 node HP Integrity cluster running Oracle 10G RAC with Red Hat Enterprise Linux 3 AS. This benchmark was only the second to achieve in excess of 1,000,000tpmC, beating the previous record holder by 17%. It used a database of approximately 90 Terabytes, deployed on a storage subsystem that included over 2000 disks. The result was approximately 50% faster than the fastest Microsoft Windows results, and 98% faster than the fastest Sun Solaris result. The benchmark also produced the lowest \$/tpmC cost of the top 10 performance-related results.

Additional benchmarks are regularly being performed with Red Hat Enterprise Linux 3. Please refer to www.redhat.com/software/rhel/benchmarks for the latest benchmark result information.

As additional benchmarks become available they are documented on the Red Hat website at <http://www.redhat.com>.

Migrating from Red Hat Linux

For customers currently using Red Hat's traditional consumer products – Red Hat Linux Personal and Professional 7.x, 8 and 9 – to run commercial applications, the benefits of migrating to the Red Hat Enterprise Linux platform

are clear. As always, however, the migration must be planned carefully if it is to be done effectively and successfully.

While there are upgrade paths between successive releases of Red Hat Enterprise Linux products, it proved impractical to create an upgrade procedure that could cover all possible scenarios when migrating from the consumer releases. Red Hat's experience with the consumer releases has shown that many systems accumulate software of unknown origin and quality over time, and that upgrading such systems reliably is extremely difficult. So, because it is important to ensure that Red Hat Enterprise Linux deployments start from a fresh, known state, Red Hat does not provide an upgrade capability from the consumer releases. This means that a migration to any Red Hat Enterprise Linux product requires a fresh installation (except where noted below).

Fortunately, the heritage of Red Hat Enterprise Linux products, which were originally based on the consumer products, makes fresh installation a straightforward exercise. Externally visible components, for example, are the same across the systems, including:

- Scripts, configuration and init files
- Device semantics
- Network setup
- File systems, partitions, mount points
- Local databases for entities such as printers and user management
- Graphics and X support

In almost all cases existing systems will be configured with separate partitions for user populations, applications and database files. These do not need to be changed during the migration process, which will only effect the root and other system partitions.

Maintenance of control scripts and local Linux datafiles is usually managed from a remote management server by the system administrator, using tools which provide management and centralized provisioning of all configuration-specific files.

Greatly simplified, the migration process will proceed as follows:

- Backup all partitions.
- If not maintained by a remote management server, identify and save all system-specific control, init, configuration and script files.
- Install the appropriate Red Hat Enterprise Linux product in the root and other system partitions.
 - The installation process is comprehensively documented in the Red Hat Enterprise Linux Installation Guide provided with the product. It is also available at <http://www.redhat.com/docs>. For system administrators experienced with Red Hat Linux 7.x, 8 and 9 releases, the installation will be familiar and straightforward.

- Restore saved control files directly or from remote management server.
- Verify application operation (see below), and test the new configuration.

After the installation has been completed features that are specific to Red Hat Enterprise Linux products can be enabled, such as Network Crashdump and Console Logging. Also, since all Red Hat Enterprise Linux systems are provided with a year's subscription to Red Hat Network (RHN), it is important to register the system with RHN in order to receive the latest errata and updates. Instructions on how to do this are included in the documentation.

Red Hat Applications

Red Hat Enterprise Linux products support a range of Red Hat Applications. These optional products can be used to enhance the base operating system, and currently include:

- Red Hat Global File System (GFS) – Is Red Hat's premier clustering capability, delivering a highly scalable cluster file system. Supported on Red Hat Enterprise Linux AS and ES, Red Hat GFS provides concurrent multi-node data sharing for easy application scaling and storage management.
- Red Hat Cluster Suite – Provides two clustering capabilities that can be used with Red Hat Enterprise Linux AS and ES: a high availability application failover capability that supports up to eight systems, and an IP Load Balancing capability that is suitable for high availability and high throughput network applications. Red Hat Cluster Suite is included as a component of Red Hat GFS.
- Red Hat Developer Suite – Described below.
- Red Hat Portal Server – Aggregates local and remote content along with various applications into an easy-to-configure web interface to best suit your organization's needs.
- Red Hat Content Management System – A complete workflow-based engine designed to manage content creation and delivery for an intranet, extranet or Internet site.

Application Migration Issues

There are a variety of issues that need to be considered when migrating to any new operating system platform, and Red Hat Enterprise Linux is not exempt from them. There are three primary migrations to be considered

- From proprietary Unix systems to Red Hat Enterprise Linux
- From Microsoft Windows to Red Hat Enterprise Linux
- From consumer Red Hat products to Red Hat Enterprise Linux

This section discusses a few of the migration issues for each of these scenarios.

Migrating from proprietary Unix

In general, Linux strives to make migrations from proprietary Unix systems as easy as possible. It does this by providing similar tools and capabilities as those found on Unix systems such as Sun Solaris, HP-UX and IBM AIX. An advantage of Linux is that most developer tools are included in the base system rather than in a separate layered product. As a result most Linux systems provide more software than the proprietary Unix systems.

Linux compilers and related tools have been designed as replacements for Unix vendor tools and provide very similar capabilities, although usage options may be different. Perhaps the most important feature for application migration is that Linux is POSIX compliant, greatly improving the portability of applications from proprietary Unix systems.

Multi-threaded applications

A feature of many Unix applications is that they are multi-threaded. Red Hat Enterprise Linux supports multi-threading, although the implementation has significantly changed and improved between version 2.1 and version 3. In Enterprise Linux 2.1 the threading capability was mostly POSIX compliant, with signal handling being the major exception. Also, performance was not comparable to the proprietary Unix operating systems. With Enterprise Linux 3 the multi-threading subsystem has been completely re-written and is now fully POSIX compliant and also provides very high performance. Heavily multi-threaded applications can now readily be ported from Unix environments.

Java applications

Java virtual machines and Just-in-Time compilers are available for Red Hat Enterprise Linux in the same way as proprietary Unix systems. Red Hat Enterprise Linux provides Java implementations from BEA, IBM and Sun, as well as the native, open source *gcj* Java compiler. The implementation that a specific deployment would use will vary based on the hardware architecture or application requirements. The “write once, run anywhere” capability of Java applications makes migrating Java applications from proprietary Unix relatively easy. In many cases applications can be migrated with no additional development or modification – although a period of testing would be recommended for an application of any size.

Migration strategy

Perhaps the most important strategy when migrating from a proprietary Unix is to take a gradual approach rather than a wholesale switchover. Given that most open source developer tools (*gcc*, etc) can be used on proprietary Unix systems, the first step is to port applications so that they successfully build using these tools running in the original Unix environment. This allows development engineers to resolve problems related to the build environment without having to worry about other problems.

Once the application works on the original Unix platform, having been built using open source tools, it can then be moved to the Red Hat Enterprise Linux

environment. Development engineers are then able to focus on operating system and processor/architecture issues exclusively – because any tools issues have already been resolved. Experience has shown that this strategy generally results in a more predictable, faster, and low risk migration.

Migrating from Microsoft Windows

Migrating to any Linux environment from Microsoft Windows is probably one of the most difficult types of migration, due to Windows' fundamentally different system design, standards and APIs. As with proprietary Unix migrations described in the previous section, it is usually best to isolate tool dependencies by running open source tools on the Windows system and using them to port the application. Cygwin (available from Red Hat) can be used to provide a Unix/POSIX-like environment on Windows, which can help isolate many operating system issues. One area where significant development effort is usually required is the graphical interface, due to the fact that they are completely different on Windows and Linux. Note that, as with Unix, customer experience has shown that migrating Java applications from Windows to Linux can be done quickly and easily.

In some cases it may be quicker and more cost-effective to eliminate the need to port a Windows application by running it in a virtual machine (VM) environment that emulates Windows on Linux. Example VM environments include Win4Lin and VMware. Windows runtime emulators, such as the open source Wine project (commercialized as Crossover Office by CodeWeavers) may also provide a workable solution.

Migrating from consumer Red Hat products

As might be expected, migrating applications from consumer Red Hat products to Red Hat Enterprise Linux is simpler than from Unix or Windows environments. The level of complexity will vary depending on the specific migration, for example, migrations to Red Hat Enterprise Linux 3 from Red Hat Linux 7.x will be more complex than from Red Hat Linux 9, due to the greater difference in their respective application build environments.

In general, however, there is a high level of compiler and runtime library compatibility across the environments, although stricter adherence to language standards in later versions may result in the need for minor application code changes. (Note that Red Hat Enterprise Linux does not provide Red Hat Linux compatibility libraries.)

Because Red Hat Enterprise Linux is generally a superset of Red Hat Linux there are few or no base operating system issues to address. The Enterprise Linux products also include additional development tools that can further simplify porting and development efforts.

Lastly, the optional Red Hat Developer Suite layered product can be used to provide a fully-featured Integrated Development Environment (IDE).

It is worth noting that the Red Hat Enterprise Linux product is tuned differently

and provides additional server performance features over the consumer Red Hat products. These can be expected to result in improved application performance on the Red Hat Enterprise Linux platform.

Considerations when upgrading Red Hat Enterprise Linux applications from version 2.1 to version 3

A feature of the Red Hat Enterprise Linux family of products is that they are maintained and supported for five years from the date of introduction. And, as an integral part of the annual subscription to the products, customers are provided with unlimited access to new releases. Consequently customers can schedule upgrades to new releases to suit their requirements.

Although upgrades from version 2.1 are supported by the Red Hat Enterprise Linux 3 installation procedure (for x86 processors), Red Hat recommends that systems are upgraded by performing a full application and data backup, followed by a fresh install of Red Hat Enterprise Linux 3 over the previous version. This recommended reinstallation method helps to ensure the best system stability possible.

Backward compatibility, the ability to run applications that were built on older releases of an operating system on newer releases, is provided with Red Hat Enterprise Linux. Enterprise Linux 2.1 compatibility libraries are provided with Enterprise Linux 3, so the majority of version 2.1 applications will run on version 3 directly, without rebuild. In general it will make sense for a version 2.1 application to be rebuilt on version 3 so that it can benefit from compiler and library enhancements, but this need not be done as an integral part of a version upgrade. Rebuilding an application on version 3 should be straightforward – experience has shown that most difficulties upgrading are caused by the application not accurately complying with an API standard. For ISVs with products that are Red Hat Certified or in the Red Hat Ready Program it will be necessary to recertify on Enterprise Linux 3 once they have completed the product rebuild.

As with any operating system environment, it is worth some effort to ensure that an application developed for one version of Red Hat Enterprise Linux will migrate easily to newer releases as they become available. Red Hat's goal is to ensure that any application which adheres to the POSIX and Linux Standards Base standards will run seamlessly from one release to another. Applications that do not adhere to these standards may not work on newer releases, or will need special handling. For applications moving from Enterprise Linux 2.1 to Enterprise Linux 3 there are three areas where special care is required:

- Changes to signal handling behavior in multi-threaded applications due to the new Native POSIX Threading Library in Enterprise Linux 3. This can usually be worked around by using an environment variable to trigger use of the older LinuxThreads threading implementation, which is provided for compatibility reasons. Refer to information on `LD_ASSUME_KERNEL` in the Release Notes.

- Link time errors caused by accessing private symbols in system libraries.
- Applications using obsolete interfaces or helper applications.

Source Code compatibility

Provision of backward compatibility of source code is not a goal for the Red Hat Enterprise Linux releases, due to the newer C++ compilers being much stricter about rejecting code that does not comply with the ISO C++ standard. A wealth of information relating to standards compliance can be found in the GCC Release Notes at: <http://gcc.gnu.org>. Note that new versions of the C++ runtime libraries (version 3) are not API compatible with older versions (including version 2). The above web site provides an FAQ which discusses migration, extensions and backward compatibility in detail (see gcc.gnu.org/onlinedocs).

Linker and runtime compatibility

The Application Binary Interface (ABI) specifies parameter passing, register usage conventions, structure layout, name parsing, virtual table layout, exception handling and other link-time and runtime conventions. Red Hat Enterprise Linux 3 implements the new C++ ABI standard. A result of this is that objects and libraries built with Enterprise Linux 2.1 tools cannot be linked together with objects and libraries built with Enterprise Linux 3 tools. So, when porting an application between the releases it is important to identify any required third party libraries for which the source code is not available. Note that a compatibility library is provided for linking old binaries against.

While the Red Hat Enterprise Linux 3 compilers are much stricter in their compliance to language standards for C++ and Java, note that the runtime environments also adhere much closer to the appropriate standards (an immediate benefit of this is that the new C++ runtime environment is thread safe and optimized for multi-threaded applications).

Red Hat Enterprise Linux 3 new technologies

Red Hat Enterprise Linux 3 provides additional tools to assist application developers. These include:

- Mudflap – a tool that provides Purify-like capabilities to detect invalid pointer operations without infringing on IBM/Rational patents.
- Oprofile – a system-wide profiler (suitable for kernel and user-mode code) that uses performance monitoring hardware located on the CPU chip to profile the entire system. This can be used to tune application performance and to monitor the overall system performance over time.
- Red Hat Developer Suite – an optional layered product that provides an Integrated Development Environment (IDE) based on the open source Eclipse project, with Red Hat specific enhancements (such as an RPM plugin). Red Hat Developer Suite is available for no charge (for an introductory period) with all Red Hat Enterprise Linux product subscriptions. Customers can download it using Red Hat Network. For details on Eclipse refer to <http://www.eclipse.org>.

- Enhanced compilers – GCC 3.2 compiler technology provided in Red Hat Enterprise Linux 3 includes a newly designed optimizer that is capable of generating higher efficiency code (primarily for Intel architecture processors).

Professional Services

For customers that do not wish to undertake the task of migrating their systems to Red Hat Enterprise Linux, Red Hat's Professional Services organization provides programs that can be tailored to do the job. Red Hat has developed specific programs to support migrations from any environment to Red Hat Enterprise Linux AS, ES and WS – from the small-scale to the very large.

Red Hat Professional Services implement an AIM model – assess, implement, manage – to guide Red Hat Enterprise Linux deployments from conception, through delivery, to ongoing support and maintenance. Red Hat works with the customer to find a solution that fits their organization, comprising professional services, support services, and training. High level features of these stages include:

- Assess – During the Assess phase of the AIM model Red Hat helps the customer to evaluate the Red Hat Enterprise Linux platform, plan their IT architecture, and design the initial rollout. Examples activities include:
 - On-site Unix to Linux consulting
 - Security assessments
 - Software evaluations
 - Hardware certification
- Implement – During the Implement phase of the AIM model Red Hat helps the customer install Red Hat software components, complete any necessary porting, and integrate applications. Example activities include:
 - C/C++ porting
 - Java porting
 - Apache/Tomcat integration
 - Database installation and integration

Also, during the Implement phase, customers typically engage with Red Hat's Global Support Services for:

- Production support via:
 - Red Hat Enterprise Linux subscriptions (AS/ES/WS)
 - Red Hat Network subscriptions
 - Red Hat Applications subscriptions
 - Technical Account Management
- Developer support through:
 - ISV Developer Support

- Premium Developer Support
- Additionally during the Implement phase, Red Hat's Global Learning Services can provide:
- On-site training for system administrators and network administrators toward RHCE certification
 - Advanced 400-level courses for your key system administrators
 - On-site developer courses
- Manage – Customers reaching the Manage phase of the AIM model have their Linux infrastructure in place and are looking to maintain operational efficiencies and extract further value from their investment. Red Hat works with the customer to help optimize performance, eliminate costs, or redeploy resources. Example activities include:
 - RHN Monitoring Configuration
 - Performance tuning
 - Updated training plans
 - Regular communication of new and updated offerings

Reference Documentation

Since the original availability of Red Hat Enterprise Linux, Red Hat and its partners have developed a number of white papers covering various technical aspects of the product. The following papers are recommended.

- Red Hat papers.
Available at: <http://www.redhat.com>
 - An Overview of Red Hat Enterprise Linux, version 3, product family. This paper provides a comprehensive description of the Red Hat Enterprise Linux family and its technologies.
 - Delivering High Availability Solutions with Red Hat Cluster Suite. This paper provides a technical overview of the optional Red Hat Cluster Suite product, which provides high availability clustering for Red Hat Enterprise Linux AS and ES products.
- Oracle papers.
Oracle provides a number of Red Hat Enterprise Linux papers, available at: <http://otn.oracle.com/tech/linux/content.html>
Additionally, details of Oracle's "Unbreakable Linux" program, developed in partnership with Red Hat, can be found at <http://www.oracle.com/redhat>.
- The Native POSIX Thread Library design white paper, available at: <http://people.redhat.com/drepper/nptl-design.pdf>

Summary

For Red Hat customers currently deploying traditional Red Hat Linux products in

commercial environments the benefits of migrating to the Red Hat Enterprise Linux family of products are clear. Platform stability, combined with performance, availability, scalability and service features make Red Hat Enterprise Linux AS, ES, WS and Red Hat Desktop compelling solutions. Also, for most proprietary Unix environments the shared heritage with Linux makes migrations to Red Hat Enterprise Linux a practical technical, and sound financial, proposition.

These products have been enthusiastically embraced by the ISV community who rapidly appreciated that they are the ideal platform on which to deploy Linux in the most complex and demanding environments. Red Hat's partners, such as Oracle, having gained considerable experience with Red Hat Enterprise Linux products, are recommending it to their customers as the Linux platform of choice.

For an existing Red Hat Linux installation the migration to a Red Hat Enterprise Linux product is not complex, despite the fact that it requires a fresh installation. The benefits will certainly outweigh the effort involved. Red Hat's Professional Services organization has programs to assist customers where necessary.

For additional information please refer to <http://www.redhat.com> or call 1-888-2REDHAT.