Virtualization has become the mainstream deployment model for enterprise data centers. The ability to consolidate infrastructure and dynamically manage workloads delivers high value, both through cost savings and increased business agility. However, not all virtualization solutions are created equal. Performance, scalability, security, and cost can vary significantly between competing solutions. The degree of openness and standards-adherence also varies, which can affect the flexibility of IT organizations looking to evolve their IT infrastructure into cloud computing environments.

Intel and Red Hat are breaking new ground across key parameters of virtualization, delivering significantly higher performance than alternative solutions, in addition to the scalability, reliability, manageability, and security needed to support the full range of enterprise applications. Intel and Red Hat provide these capabilities on one of the industry’s most open computing architectures with cost models that make end-to-end virtualization truly affordable.

Two recent advances by Intel and Red Hat are particularly important.

- **Scalable Intel® Xeon® processor E7-based servers** enable end-to-end data center virtualization. Four-socket, eight-socket and larger servers based on the Intel Xeon processor E7 family deliver the scalable performance needed to support large enterprise workloads in virtual environments, including demanding transactional, database, and analytics applications. These servers also provide a foundation for high-availability and advanced security, enabling IT organizations to extend virtualization into the heart of their data centers with confidence.

- **Red Hat® Enterprise Virtualization erases traditional boundaries.** Because the Kernel-based Virtual Machine (KVM) hypervisor is integrated into the Linux kernel, Red Hat Enterprise Virtualization automatically inherits the advanced capabilities of Red Hat’s enterprise-proven Linux operating system. This mechanism has helped Intel and Red Hat deliver leadership performance, scalability, and security in virtualized environments in less than a year after the initial release of KVM. It also allows Red Hat to maintain consistent application binary interfaces across bare-metal, virtual, and cloud environments, so IT organizations can move applications with confidence across all three environments, with no need for modification or recertification.

**World-Record Virtualization Performance**

The Red Hat® Enterprise Virtualization Hypervisor (RHEV-H) (based on Red Hat® Enterprise Linux® 6) and the Intel Xeon processor E7 family have demonstrated world-record virtualization performance across a wide range of server configurations (Figure 1). Intel® Virtualization Technology2 (Intel® VT) establishes the foundation for this exceptional performance at the silicon level by providing comprehensive hardware assists for virtualization in Intel® processors, chipsets, and network adapters. KVM takes advantage of Intel VT to enable higher throughput with reduced latencies. Because KVM is fully integrated into the Red Hat Enterprise Linux kernel, it also leverages the many performance optimizations in Red Hat Enterprise Linux, such as improved NUMA support, ticketed spinlocks, transparent huge pages, and a number of important scheduling innovations. These optimizations help improve performance, efficiency, and resource utilization in today’s highly scalable server configurations.

<table>
<thead>
<tr>
<th>Virtualization Performance (SPECvirt_sc2010)</th>
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<tr>
<td>Intel® Xeon® processor E7 family and Red Hat® Enterprise Linux® 6</td>
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<td>World Record: 7424@456 VMs</td>
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<tr>
<td>World Record: 2144@132 VMs</td>
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Figure 1. The Red Hat® Enterprise Virtualization Hypervisor (based on Red Hat® Enterprise Linux® 6) and the Intel® Xeon® processor E7 family have demonstrated world-record virtualization performance across a wide range of server configurations.
Scalability for Enterprise Workloads

An eight-socket server based on the Intel Xeon processor E7 family provides up to 80 cores, 160 threads, and 4 terabytes of memory to support heavy enterprise workloads. Red Hat Enterprise Linux with integrated KVM delivers comparable scalability in the virtual environment. The software is designed and written to support up to 64 virtual CPUs and 64 TB of memory per virtual machine, with no effective limit on the number of virtual machines per physical server. IT organizations can take advantage of this support to scale their virtual environment up or out as needed, so they can optimize performance and resource utilization based on workload requirements.

One of the most important technologies in the latest Intel and Red Hat product releases is Single Root I/O Virtualization (SR-IOV), an extension to the PCI specification that was driven by Intel and Red Hat. SR-IOV enables efficient sharing of physical I/O devices in virtualized environments, with near-native performance, tunable bandwidth, and a high level of traffic isolation. It eliminates one of the key roadblocks to pervasive virtualization by allowing IT organizations to virtualize and consolidate I/O-intensive workloads, such as high-volume databases and transactional applications. It also enables more efficient use of available network and SAN ports to simplify connectivity and reduce related costs.

Mission-Critical Availability in Virtual Environments

Thousands of enterprise customers are already running mission-critical applications on Red Hat Enterprise Linux and Intel Xeon processor-based servers, including industry leaders such as Gap, Inc., NYSE Euronext, Sabre Holdings, Salesforce.com, and Wall Street Systems. As noted by Timothy Nolan, IT manager for UNIX/Linux Engineering at Travelers Insurance, “Intel Xeon processors and RHEL have come a long way in supporting mission-critical workloads. Our workload at Travelers, previously relying on IBM’s AIX platform, can now reliably be supported on the Intel/Red Hat platform. We are very happy with the performance improvement as well as the price per performance and did not have to compromise any of the capabilities and reliability features we previously enjoyed on UNIX platforms.”

Intel is driving technology advances that continue to deliver increasing mission-critical capability. The Intel Xeon processor E7 family includes an array of reliability, availability, and serviceability (RAS) features, including extensive error correction and automated system recovery. Intel and Red Hat have worked closely to provide integrated support for these features in Red Hat Enterprise Virtualization and Red Hat Enterprise Linux 6.

Red Hat also provides advanced mission-critical capabilities throughout the software stack, with integrated features such as Control Groups, which provides fine-grained, policy-based control over resource allocation in both virtualized and non-virtualized environments. As an example, Control Groups could be used to allocate 25 percent of network bandwidth to each of four virtual machines to ensure that one virtual machine could not degrade the network performance of the others. Other integrated capabilities include high-availability clustering with automated failover, advanced error management, and predictive failure analysis.

Strong Security to Reduce Risk

Many companies are concerned with security risks in virtualized environments. Red Hat® SELinux is one of the world’s most secure operating environments. Developed jointly by Red Hat and the United States National Security Agency (NSA), SELinux works in tandem with the hardened Red Hat Enterprise Linux kernel to isolate systems and workloads by providing fine-grained, policy-based control over virtual machine access. Intel VT complements these security measures by providing better isolation among virtual machines at the silicon level. It also offloads core virtualization tasks into hardware, which makes it easier for Red Hat to maintain its lean, security-hardened hypervisor environment.

The latest Intel Xeon processors add to these safeguards with two new Intel technologies.

• **Intel® Advanced Encryption Standard-New Instructions (Intel® AES-NI)** helps to accelerate core cryptographic processes and reduce the performance overhead of using encryption. As a result, IT organizations can implement encryption more pervasively to protect business data, not only at rest, but also as it moves through the virtualized data center and ultimately into the cloud. Intel AES-NI is currently supported for components of Red Hat Enterprise Linux running directly on the host server. It will be supported for AES-based encryption running in virtual machines in Red Hat Enterprise Linux 6.3, due for release in the near future.
Intel® Trusted Execution Technology (Intel® TXT) allows IT to establish “trusted infrastructure,” by validating systems to ensure that the system has not been compromised by low-level malware. This occurs during the launch of physical machines, before any virtual machines have been launched. It also provides information that can be used to monitor and verify security and compliance in bare-metal, virtualized, and cloud environments.

Fast Forward
Intel and Red Hat collaborate extensively to deliver complete, integrated, and tested enterprise solutions supported by a global community of hardware, software, and service providers. Customers receive a high level of integrated functionality and comprehensive support, with low and predictable costs. They also have the flexibility to upgrade at their own discretion, and without incurring additional costs, since upgrades and patches are fully covered by their subscription.

Efficient Management of Physical and Virtual Assets
Realizing the full value of virtualization depends on being able to efficiently manage today’s complex physical and virtual environments. The Red Hat® Enterprise Virtualization Manager (RHEV-M) and the Red Hat® Network provide comprehensive and integrated control of physical and virtual systems from a centralized console, with support for live migration, failover clustering, automated load balancing, power optimization, and rapid provisioning.

Red Hat’s unique, search-based approach helps to cut through the complexity of virtual and physical environments. IT staff can efficiently locate and group physical and virtual systems based on both fixed and dynamic variables. For example, an IT administrator could quickly find “all hosts using more than 85 percent of their physical memory.” With these tools, administrators can manage dozens or even hundreds of virtual machines as easily as one.

Intel Virtualization Technology, the Red Hat Enterprise Virtualization Hypervisor (RHEV-H), and the Red Hat Enterprise Virtualization Manager (RHEV-M) help to increase the value of these capabilities across the data center. By supporting the live migration of virtual machines across current and future Intel Xeon processor generations, it enables IT organizations to maintain a single pool of virtualized resources.

Importantly for many customers, Intel and Red Hat simplify integration with VMware and Microsoft environments. Red Hat supports interoperability of RHEL and RHEV with other operating systems and hypervisors, and Intel Xeon processor-based servers ensure optimized performance across the widest range of mixed software scenarios. This openness makes it easier for IT organizations to extend existing infrastructure and efficiently manage mixed environments.

The Platform of Choice for the Cloud
Red Hat Enterprise Virtualization and Intel Xeon processor-based servers have become the platform of choice for leading public cloud providers and an increasingly popular choice for private clouds. Intel and Red Hat offer complete reference architectures and implementation guides to help customers plan, build, and manage public and private clouds. Companies such as Amazon, DreamWorks Animation, and NTT Communications have chosen the combined platform for large-scale cloud deployments.

As companies extend virtualization in their data centers, Intel and Red Hat provide one of the industry’s most powerful, cost-effective, and flexible solutions, one that delivers exceptional value today, while providing a smoother path toward next-generation cloud computing models.

For more information, visit www.intel.com/xeon and www.redhat.com/virtualization/rhev/server.

Intel® Virtualization Technology requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM). Functionality, performance or other benefits will vary depending on hardware and software configurations. Software applications may not be compatible with all operating systems. Consult your PC manufacturer. For more information, visit http://www.intel.com/go/virtualization

For more information on these and other technologies in Red Hat Enterprise Linux 6, visit http://www.redhat.com/rhel/server/features/benefits.html.

Red Hat Enterprise Linux is currently certified for up to 2 terabytes of memory in a standard configuration. Larger memory configurations require special certification.

Intel® AES-NI requires a computer system with an AES-NI enabled processor, as well as non-Intel software to execute the instructions in the correct sequence. AES-NI is available on Intel® Core™ i5-600 Desktop Processor Series, Intel® Core™ i7-600 Mobile Processor Series, and Intel® Core™ i5-500 Mobile Processor Series. For availability, consult your reseller or system manufacturer. For more information, see http://software.intel.com/en-us/articles/intel-advanced-encryption-standard-instructions-aes-ni/.

No computer system can provide absolute security under all conditions. Intel® Trusted Execution Technology (Intel® TXT) requires a computer system with Intel® Virtualization Technology, an Intel TXT-enabled processor, chipset, BIOS, Authenticated Code Modules and an Intel TXT-compatible measured launched environment (MLE). Intel TXT also requires the system to contain a TPM v1.s. For more information, visit http://www.intel.com/technology/security.

Enterprise Linux 6.1 and is implementing boot support for Intel® Trusted Execution Technology in Red Hat Enterprise Linux 6.2.

Performance will vary depending on the specific hardware and software you use. See http://www.intel.com/info/hyperthreading/ for more information including details on which processors support HT Technology. Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing. For more information on performance tests and on the performance of Intel products, visit http://www.intel.com/performance/resources/limits.htm or call (U.S.) 1-800-628-8686 or 1-916-356-3104.

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