Virtualizing Enterprise SAP® Software Deployments

A Proof of Concept by HP, Intel, SAP, SUSE, and VMware

Solution provided by:

SAP Co-Innovation Lab

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EXECUTIVE SUMMARY

Recent advances in the ability of open system computing solutions to handle virtualized enterprise workloads offer major cost advantages for large businesses. Some businesses have reduced three-year total cost of ownership (TCO) for their SAP® software implementations by as much as 80 percent[1] through virtualization and consolidation on industry-standard servers. They have also improved service levels by taking advantage of live migration functionality to control systems and workloads more effectively.

A number of industry developments have combined to deliver advanced mission-critical capability for SAP applications running on virtualized Intel® Xeon® processor-based servers:

- Near-native virtualized performance on servers with up to 80 processor cores, 2 terabytes (TB) of memory, and 16 I/O slots enables consolidation of large workloads and complex SAP software landscapes.

- Reliability, availability, and serviceability (RAS) have improved across the solution stack, including hardware, operating system (OS), and virtualization layers. Industry-standard solutions can now deliver the reliability traditionally associated with high-end UNIX*/RISC solutions, but at much lower costs.

- Multiple vendors are collaborating to provide customers with integrated solutions and services, which reduces the cost and risk of deployment.

This paper describes key hardware and software advances that are especially relevant for supporting mission-critical SAP software deployments. It also describes a proof of concept (PoC) performed by HP, Intel, SAP, SUSE (a business unit of The Attachmate Group), and VMware at SAP Co-Innovation Lab in Palo Alto, California. Results showed near-linear scalability for a heavy ERP workload deployed to virtual machines (VMs) in a three-tier configuration running on a single physical server. A two-socket server based on the Intel Xeon processor 5600 series was shown to support up to 2,100 concurrent users with an average response time of less than one second. An eight-socket HP ProLiant™ DL980 server based on the Intel Xeon processor 7500 series was able to support up to 8,000 concurrent users with a sub-second average response time.

The information in this paper is useful for IT and data center managers looking for ways to reduce TCO for their SAP software implementations. It will help them estimate the value of virtualizing and consolidating their SAP software workloads on HP servers running SUSE® Linux Enterprise Server and VMware vSphere™. It will also provide them with baseline parameters for sizing and configuring their infrastructure in the most economical way to deliver desired performance for a designated number of users.

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[1] Source: "TCO and ROI analysis of SAP Landscapes using VMware Technology." VMware, September 2009.
  http://www.vmware.com/files/pdf/partners/sap/SAP_TCOROI_Customers_Final.pdf

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Reining in SAP Infrastructure Requirements

Companies rely on SAP Business Suite software to support a wide range of mission-critical processes and to provide information and insights that help them make better business decisions. As the foundation for SAP Business Suite, the SAP NetWeaver® technology platform embraces a modular, integrated, service-oriented architecture (SOA). This architecture allows these companies to integrate diverse systems more easily and adapt processes quickly as their business grows and requirements change.

Because the functionality of SAP software is comprehensive, enterprise implementations can be complex. Businesses often have multiple SAP applications, each with its own development, quality assurance, and production environments. An enterprise implementation may entail hundreds of servers, and without careful architectural design and governance, this can result in high capital expenditures, a large data center footprint, and high operational costs.

Recent advances in open system computing solutions offer a path for simplifying and consolidating distributed SAP infrastructure, and for moving off costly mainframe and UNIX®/RISC architectures (Figure 1). This can help businesses significantly reduce their TCO. A report by VMware provides a detailed TCO analysis for three companies that have virtualized and consolidated their SAP software implementations. Total cost savings range from 40 percent to more than 80 percent, with the greatest savings being realized by companies migrating from UNIX/RISC architectures.[2] At a time when most IT budgets are flat or declining, virtualization and consolidation of SAP software landscapes can be an important strategy for redirecting resources into innovative projects that deliver higher value to the business.

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[2] Source: "TCO and ROI analysis of SAP Landscapes using VMware Technology." VMware, September 2009.
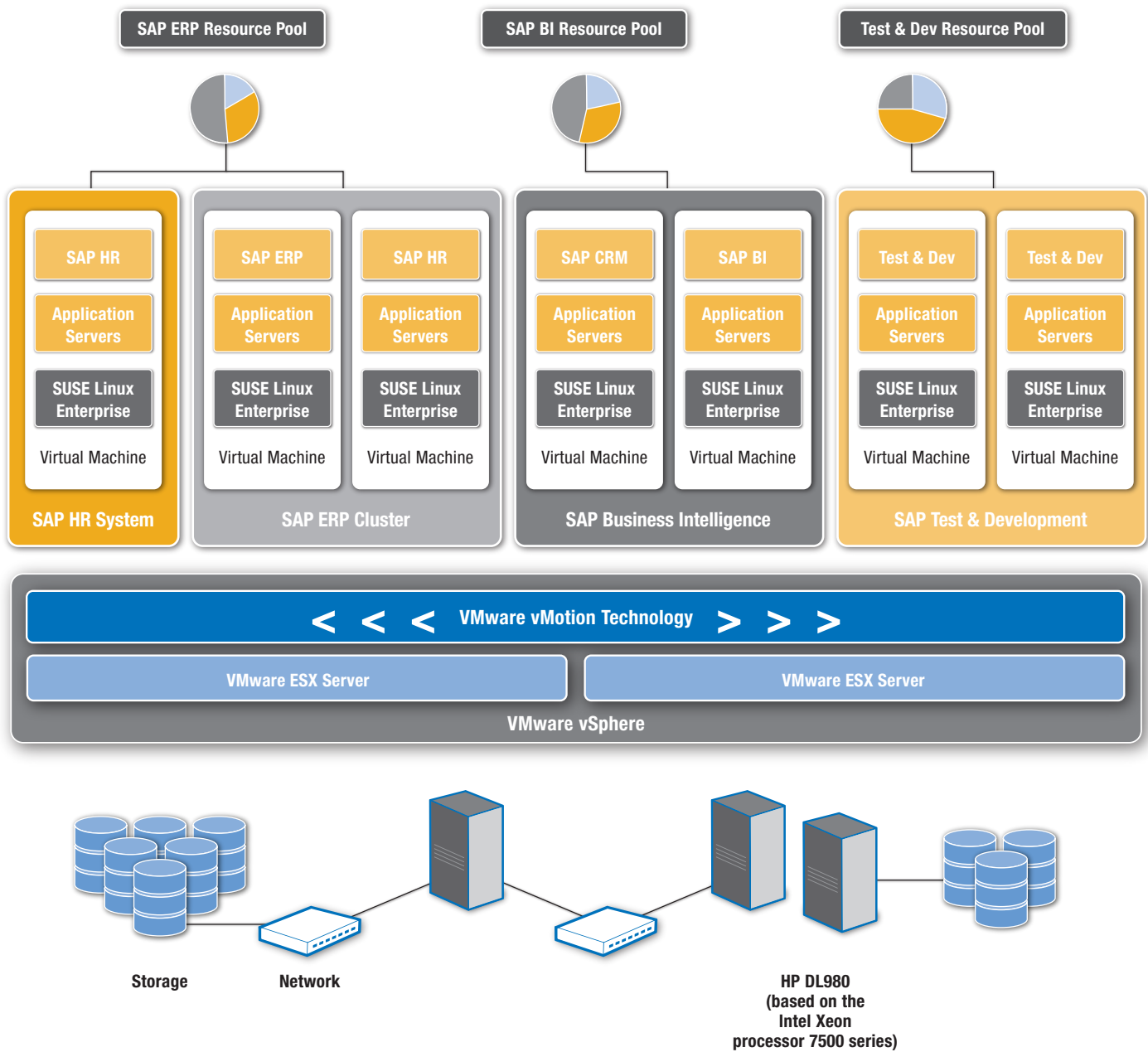
Figure 1. Virtualizing and consolidating SAP software landscapes onto eight-socket and larger Intel Xeon processor-based servers running VMware vSphere™ can improve business agility and dramatically reduce data center footprints

Mission-Critical Capability on High-Value Infrastructure

SAP software was originally designed for mainframe computing environments. With the release of SAP R/3® software in 1992, the company expanded its reach by supporting client server architectures across multiple computing platforms. Two years later, Intel and SAP began working together to deliver optimized solutions.

Today, roughly 75 percent of SAP software installations are deployed on Intel® processor-based servers, including many large enterprise implementations. In most cases, these implementations are deployed on relatively large numbers of distributed four-socket or smaller servers. The latest Intel Xeon processor-based servers from HP, combined with software from SUSE and VMware, provide the scalability and reliability needed to consolidate these distributed infrastructures onto a much smaller number of enterprise-class servers. The combined solution provides a dense, resilient, virtualized hardware infrastructure that SAP certifies and supports. IT organizations can use it to:

- **Consolidate their SAP software landscapes** to improve server utilization, reduce costs, and free up data center resources

- **Provide capacity on demand** by dynamically adding or reconfiguring VMs based on workloads and policies, enabling IT to deliver more

predictable and reliable performance to business users and to use available capacity more efficiently

- **Deploy new applications more quickly** by creating new VMs on existing systems to eliminate the costs and delays of adding physical infrastructure

- **Move running VMs among physical servers** for workload balancing, zero-downtime maintenance, high availability, and disaster recovery

- **Quickly clone production environments** to enable higher-quality development and testing, without the need to purchase and manually provision servers

Advanced Scalability and Reliability at the Hardware Level

The launch of the Intel Xeon processor 7500 series marked a tipping point for businesses interested in running heavy, mission-critical workloads on standards-based servers. These processors provide up to eight cores and 16 logical CPUs[3] per server socket, and are designed to support two-socket, four-socket, eight-socket, and larger server configurations. The follow-on Intel Xeon processor E7 family provides additional resources—up to 10 cores and 20 logical CPUs per server socket. These processor families are pin-compatible to enable simple upgrades of existing servers. Both processor families include a point-to-point interconnect subsystem and integrated memory controllers, which increase memory bandwidth

by up to eight times versus the earlier Intel Xeon processor 7400 series.[4] This additional bandwidth can deliver significant performance benefits for memory-intensive SAP applications running on large, multi-processor servers.

The Intel Xeon processor 7500 series and the Intel Xeon processor E7 family also provide an array of mainframe-inspired reliability features. Advanced error detection and correction mechanisms are implemented across all processor cores and communication pathways. Integrated functionality has also been added to enable automated, OS-assisted recovery from many previously fatal errors, and this capability is fully supported in SUSE Linux Enterprise Server 11 Service Pack 1.

HP has built on this foundation to provide advanced mission-critical capability in its ProLiant DL980 G7 server. This eight-socket server provides up to 80 cores, 160 logical CPUs, and 2 TB of memory (up to 4 TB with future 32 GB DIMMs). A new shared cache architecture helps increase system response times in these large servers by improving memory latency.

Enterprise SAP deployments are typically I/O-intensive, and the HP ProLiant DL980 G7 server family provides up to 16 I/O slots per system to address heavy storage and network connectivity requirements. These slots can be used to provide dedicated connections. They can also be virtualized and shared across

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[3] Each processor core of an eight-core Intel® Xeon® processor 7500 series supports Intel® Hyper-Threading Technology and is capable of handling two simultaneous software threads. The operating system perceives this as two distinct sets of processing resources, or "logical CPUs." (In a virtual environment, each logical CPU is designated as a virtual CPU (vCPU).)

[4] More than 8x memory bandwidth claim is based on Intel internal measurements made using Intel internal memory bandwidth workloads running on a 4-socket Intel® Xeon® processor X7560 based server and a comparably configured 4-socket Intel® Xeon® processor X7460 server, as of February, 2010. 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.

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multiple VMs to simplify network and storage connectivity, and to improve utilization of available ports within the data center.

HP ProLiant DL980 servers are built for mission-critical workloads, providing up to 200 percent higher availability than previous-generation systems.[5] Part of this gain comes from the silicon-based RAS features in the Intel Xeon processors, which provide a foundation for improved error logging, analysis, containment, and recovery. Additional gains come from a new HP system interconnect fabric that provides redundant data paths and dynamic routing, with 50 percent more link capacity.

Mission-Critical Capability in an Open Source Operating System

SUSE Linux® Enterprise Server 11 Service Pack 1 provides the best of open source Linux in a tightly-integrated, highly-tested distribution designed for mission-critical deployments. It delivers excellent performance and scalability, as demonstrated by its wide adoption in both enterprise and high-performance computing (HPC) environments.[6]

SAP and VMware recommend SUSE Linux Enterprise Server for Linux deployments. It supports the advanced performance and high-availability features of the latest Intel Xeon processors and scales to take full advantage of all available hardware resources on current and future server platforms. SUSE Linux Enterprise Server provides integrated virtualization capabilities and is also

optimized as a guest OS running in VMware vSphere VMs. The cost savings versus proprietary UNIX OSs can be considerable. This is especially true in virtualized environments, since SUSE allows unlimited VM instances with a single subscription.

The SUSE Linux Enterprise High Availability Extension, an add-on product for SUSE Linux Enterprise Server, offers a stable, robust, and direct method for clustering servers to provide high availability for SAP applications. SAP fully supports this high-availability solution. It includes dedicated SAP resource agents and provides automated failover, a clustered file system, clustered logical volume management, and data replication.

Alternatively, some customers may choose to implement VMware High Availability and VMware Fault Tolerance solutions, as described in the next section. VMware high-availability solutions monitor health at the VM level, while the SUSE Linux Enterprise High Availability Extension monitors health at the application level, and includes the ability to restart and migrate processes. (By following the VMware Knowledge Base Article 1034165, which can be found at http://kb.vmware.com/kb/1034165, it is possible to deploy SAP software with SUSE Linux Enterprise High Availability Extension inside VMware VMs. Such a solution combines the benefits of SAP application health monitoring provided by clustering software with the flexibility and agility provided by a VMware virtualized platform.)

Enterprise-Class Virtualization

VMware vSphere takes advantage of Intel Virtualization Technology (Intel VT) to provide scalable support for mission-critical enterprise workloads (Table 1) with:

- **Near-native performance in VMs.** The performance overhead for virtualization has been measured at 5 to 7 percent.[7] Because of the superior performance of the latest servers, customers can expect to see significant performance improvements when they virtualize and consolidate workloads from older systems.

- **Scalable capacity.** VMware vSphere 4 supports up to eight virtual CPUs (vCPUs) and 255 gigabytes (GB) of memory per VM, providing sufficient capacity for all but the most extreme enterprise workloads.

- **High-bandwidth, low-latency I/O.** With support for up to 30 Gb/s of network bandwidth per VM and more than 300,000 I/O operations per second, vSphere can support the I/O-intensive workloads that are common in SAP software implementations. IT organizations can configure direct connections between I/O devices and VMs, which eliminates most or all of the overhead associated with older, software-based I/O virtualization. I/O bandwidth can also be shared among multiple VMs to maximize utilization of limited storage or network ports.

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[5] Based on an HP internal study comparing system crash rates between the ProLiant™ DL980 G7 and the DL785 G5. System crash rate is determined by availability features such as hot-swap components, resilient paths, ECC, and the fault-tolerant links provided by Intel® QuickPath Interconnect Technology.

[6] Linux® is currently used in more than 90 percent of the world's largest supercomputing systems, and SUSE® Linux Enterprise is one of the most widely used Linux distributions. For more information, visit www.TOP500.org.

[7] Source: SAP on vSphere 4.1 performance comparison study conducted by VMware performance engineering. http://blogs.vmware.com/performance/2010/08/sap-performance-on-vsphere-41-with-db2-and-suse-10.html

Table 1. Physical and virtual scalability for large workloads

Available Resources	Per Physical Server	Per Operating System Image	Per Virtual Machine
	HP ProLiant™ DL980 G7	SUSE® Linux Enterprise Server 11 SP1	VMware vSphere™ 4
CPU	8 sockets (80 cores/160 logical CPUs)[a]	4096 logical CPUs	8 vCPU
Memory	2 TB (128 DIMMs)	16 TiBb[b] (certified)	255 GB
I/O	16 slots (dedicated or shared bandwidth per slot)	12,000 SCSI devices	Network: 30 Gb/s IOPS: > 300,000

[a] Each processor core of an eight-core Intel Xeon processor 7500 series supports Intel Hyper-Threading Technology and is capable of handling two simultaneous software threads. The operating system perceives this as two distinct sets of processing resources, or "logical CPUs." In the virtual environment, each logical CPU is designated as a virtual CPU (vCPU).

[b] 1 TiB = 1 tebibyte = 2^{40} bytes. SUSE uses IEC binary prefixes to avoid the potential confusion associated with the use of SI decimal prefixes (for example, terabyte) in some binary applications.

VMware vSphere provides a number of operational advantages. Enhanced VMware vMotion® and Intel VT FlexMigration provide an enterprise-proven live migration solution for moving running VMs across current and future Intel Xeon processor-based servers. This functionality can be used for workload balancing and for performing physical maintenance without downtime. It also provides the foundation for VMware's business continuity solutions.

- **VMware High Availability** monitors VM health and can be configured to automatically restart a failed VM on the same or a different physical server.

- **VMware Fault Tolerance** maintains mirrored operation in a standby VM to provide automated failover with no downtime or data loss.

- **VMware vCenter™ Site Recovery Manager** enables IT organizations to automate disaster recovery processes between data centers. It eliminates the complexity and human error associated with manual processes and can also be tested without disrupting production systems.

Mission-Critical Service and Support

HP, SAP, SUSE, and VMware have developed strategic partnerships to deliver integrated service and support for mission-critical deployments. Customers can choose from a variety of support models based on specific requirements.

- HP offers comprehensive, mission-critical support for SAP applications running on VMware vSphere and SUSE Linux Enterprise Server. Offerings include:

  - Proactive services to optimize the solution for high availability, performance, security, and fast recovery

  - On-site and off-site experts with detailed knowledge of a customer's hardware and software environment

  - Real-time integrated tracking between HP, SAP, and the customer help desk, for coordinated problem resolution

- SAP and SUSE offer integrated technical support through the SAP Solution Manager application management solution. Customers have 24x7 access to SAP and SUSE

technical experts with a single point of entry. (This includes the ability to directly open a service request for SUSE Linux Enterprise Server from within SAP Solution Manager). This integrated support solution ensures that technical support staff from both companies have access to complete and consistent information and can work together efficiently to solve customer problems quickly.

- VMware distributes and supports the SUSE Linux Enterprise Server operating system. This helps reduce costs and further simplifies management, since customers can get patches, updates, and support directly from VMware.

Verifying Scalability of SAP Software on an Eight-Socket Server

Intel, HP, SAP, SUSE, and VMware performed a collaborative PoC to verify scalability of SAP software workloads running on a virtualized, eight-socket Intel Xeon processor-based server. Performance was first measured using the same workload on a two-socket Intel Xeon processor-based server to provide a baseline for comparison. Performance was

then measured on the larger server to determine scalability. The tests took place in SAP Co-Innovation Lab in Palo Alto, California. This global network of labs helps accelerate innovation for SAP-related solutions by providing SAP partners with lab resources and access to leading-edge—and sometimes pre-release—software and hardware.

Test Methodology

A deployment of the SAP ERP application typically includes a single central instance (CI) of the application software plus one or more dialog instances (DIs). Though the CI can also support user processes, the DIs are primarily responsible for supporting users as they execute transactions.

To measure scalability, a three-tier SAP software environment was installed on each physical server under test (Figure 2). The database and CI were installed in a single VM. One or more DIs were also installed, each in a separate VM. The number of concurrent users supported by an optimal number of DIs is the primary factor determining scalability. To provide clear results, the number of virtual CPU cores assigned to each DI and the SAP parameters for each DI were held constant throughout the test.

The hardware and software versions reflected the latest available releases at the time of the PoC (Table 2). Performance for each server was measured using a standard workload based on a sell-from-stock scenario that includes the creation of a customer order and corresponding delivery, plus movement of goods and invoicing.
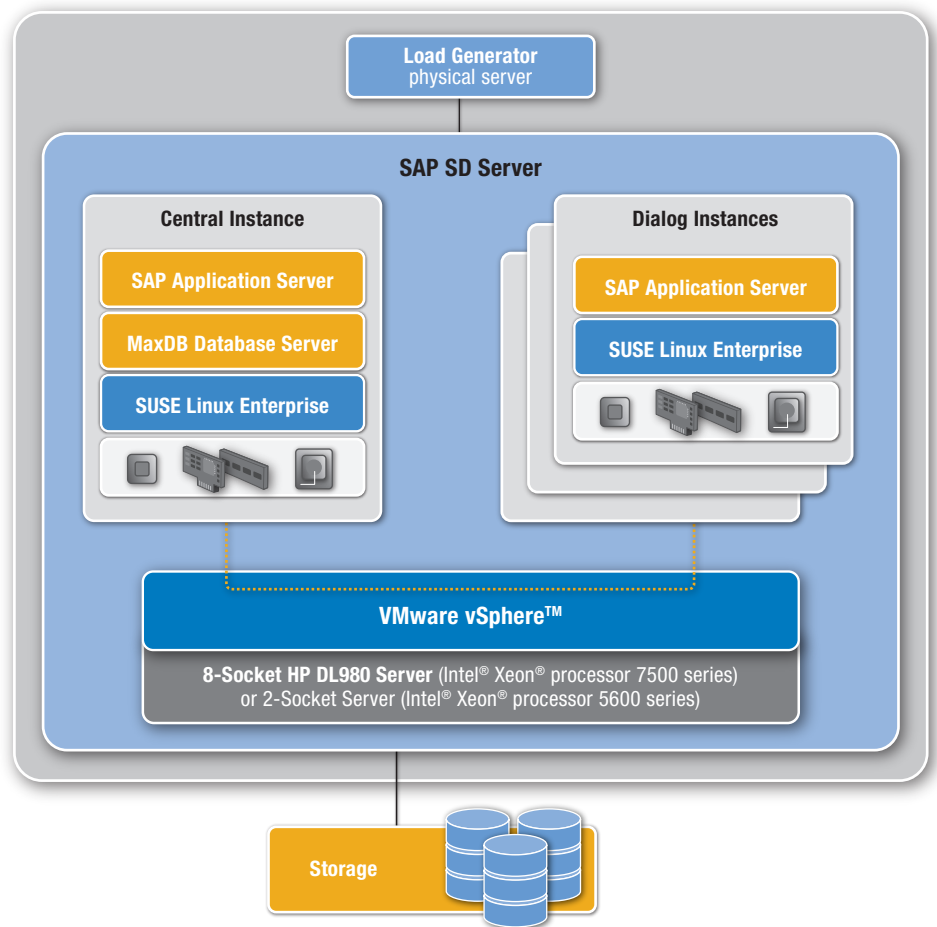

Figure 2. A complete three-tier SAP ERP application was virtualized and consolidated onto a single two-socket server and then onto an eight-socket server. Performance was measured on both systems to quantify the scalability advantages of the larger server.

Because the goal was to provide customers with usable data, out-of-the-box hardware and software were used. No detailed performance tuning was implemented at the hardware or OS levels, and SAP optimizations were based on procedures that would be employed in a typical user environment.

Scalability was measured by increasing the number of DIs. Each time a DI was added, the workload was progressively increased and response times were measured. The performance result for each test run was defined as the maximum number of concurrent users the platform could support with an average response time of less than one second. Using this process, testers were able to determine the optimal number of DIs that could be employed without over-committing hardware resources, as well as the maximum number of concurrent users that could be supported by that configuration without exceeding the one second response time.

Results: Up to 90 Percent of Full Linear Scalability

The two-socket and eight-socket servers both scaled well as additional DIs were added.

• **The two-socket Intel Xeon processor 5600 series-based server** performed best with five DIs in five virtual machines, at which point it was able to support up to 2,100 concurrent users with a sub-second average response time.

• **The eight-socket Intel Xeon processor 7500 series-based server** performed best with 14 DIs in 14 virtual machines, at which point it was able to support up to 8,000 concurrent users with a sub-second response time.

Based on these results, an eight-socket Intel Xeon processor 7500 series-based server provides up to 3.8x the performance of a two-socket Intel Xeon processor 5600 series-based server for SAP software workloads. This corresponds to better than 90 percent of full linear scalability (Figure 3).
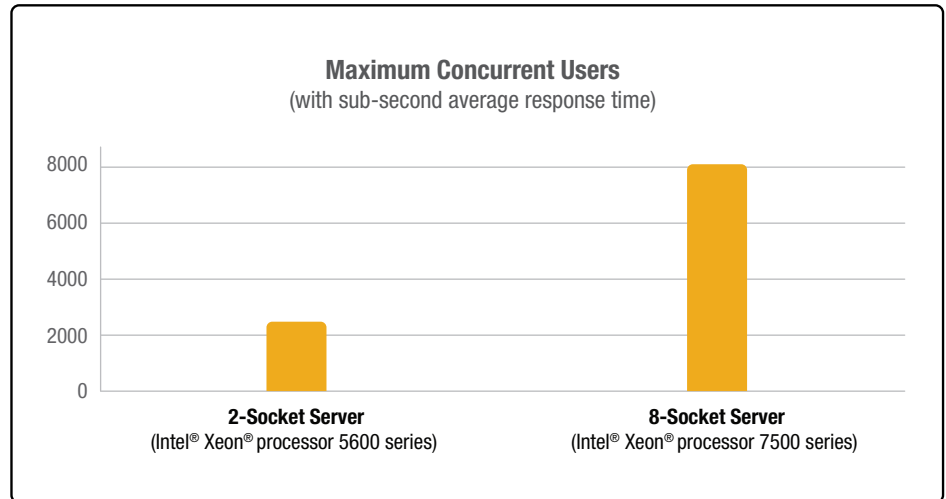

Maximum Concurrent Users
(with sub-second average response time)

Figure 3. The eight-socket Intel Xeon processor 7500 series-based server delivered 3.8x the performance of the two-socket Intel Xeon processor 5600 series-based server (better than 90 percent of full linear scalability).

Additional Considerations

• Performance results for the eight-socket server were obtained using the Intel Xeon processor 7500 series. Even better scalability per server could be expected using the more recent Intel Xeon processor E7 family, which provides more cores and cache per processor.

• The Intel Xeon processor 7500 series provides more cores than the Intel Xeon processor 5600 series, but each core operates at a lower frequency (to optimize performance versus power consumption). This helps explain why the eight-socket server delivers somewhat lower scalability per core (about 70 percent), but near-linear scalability per server.

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Table 2. Test Configurations

HARDWARE		
	Two-Socket Server	**Eight-Socket Server**
Platform	Intel white box	HP ProLiant™ DL980
Processor	2 x Intel® Xeon® Processor X5650	8 x Intel® Xeon® Processor X7560 series
Processor Details	2.66 GHz/6.4 GT/sec Intel® QuickPath Interconnect	2.26 GHz/6.4 GT/sec Intel® QuickPath Interconnect
Cores per Processor/Cores per Server	6/12	8/64
Third Level Cache per Socket	12 MB	24 MB
Intel® Hyper-Threading Technology[a]		
Intel® Turbo Boost Technology[b]	Enabled in all test runs	
NUMA		
Memory (total per server)	96 GB RAM: 12 x 8 GB DIMMs 1066 MHz DDR3	512 GB RAM: 32 x 16 GB DIMMs 1066 MHz DDR3
VM Resource Allocations CI and Database Per DI	4 vCPU, 16 GB 4 vCPU, 8 GB	8 vCPU, (128 GB or 176 GB)[c] 4 vCPU, 16 GB
Storage	Storage Disks: 48 x 300 GB Fiber Channel Raid type: Vendor-specific RAID-DP Server-to-switch connection: 10 GB Ethernet (dual port) Switch-to-storage connection: 10 GB Ethernet (three links)	
SOFTWARE		
Application	SAP Version: SAP ECC 6.0 enhancement package 4	
Hypervisor	VMware vSphere™ 4.1	
Guest Operating System	SUSE® Linux Enterprise Server 11 SP1 with Kernel v 2.6.32.12	
Database	MaxDB, version 7.7	

[a] Intel® Hyper-Threading Technology (Intel® HT Technology) requires a computer system with a processor supporting Intel HT Technology and an Intel HT Technology-enabled chipset, BIOS, and operating system. Performance will vary depending on the specific hardware and software you use. For more information including details on which processors support HT Technology, see http://www.intel.com/info/hyperthreading.

Intel may make changes to specifications and product descriptions at any time, without notice.

[b] Intel® Turbo Boost Technology requires a platform with a processor with Intel Turbo Boost Technology capability. Intel Turbo Boost Technology performance varies depending on hardware, software, and overall system configuration. Check with your platform manufacturer on whether your system delivers Intel Turbo Boost Technology. For more information, see http://www.intel.com/technology/turboboost.

[c] For test runs with 14 and 16 DIs, 128 GB of memory was allocated to the virtual machine running the CI and database. For test runs with 20 DIs, 176 GB was allocated.

CONCLUSION

Businesses are virtualizing and consolidating SAP software landscapes on Intel Xeon processor-based servers to reduce TCO by as much as 80 percent, and to improve service levels and business agility through more flexible and dynamic control of resources. HP ProLiant DL980 servers running VMware vSphere and SUSE Linux Enterprise Server offer a highly scalable and resilient platform for mission-critical SAP software implementations. The combined solution is certified and fully supported by SAP.

As demonstrated at the SAP Co-Innovation Lab, a single Intel Xeon processor 7500 series-based HP ProLiant DL980 server in a three-tier virtualized configuration can support up to 8,000 concurrent users with an average response time of less than one second. This is approximately 3.8 times the performance of a two-socket server based on the Intel Xeon processor 5600 series, delivering better than 90 percent of full linear scalability. Customers can expect even better scalability using HP ProLiant DL980 servers configured with the more recent Intel Xeon processor E7 family.

With this proven performance and scalability, enterprise IT organizations can virtualize and consolidate larger SAP landscapes onto fewer systems to simplify the hardware environment and to reduce data center space, power, and cooling requirements. In the process, they can substantially reduce TCO for their SAP infrastructure and establish a more flexible and dynamic environment for expanding their core business solutions.