WHITE PAPER
Intel® Xeon® Processor E7 Family
Microsoft SQL Server* 2008 R2

New Database Options for Scalability and Performance in the Mission-Critical Enterprise

Microsoft SQL Server* 2008 R2 running on servers based on the Intel® Xeon® processor E7 family demonstrates an excellent migration opportunity away from the cost and inflexibility of legacy proprietary RISC architectures.

Deploying Microsoft SQL Server* 2008 R2 on servers based on the Intel® Xeon® processor E7 family has become an increasingly popular choice for mission-critical enterprise applications. Migrating from proprietary databases on RISC*-based hardware can dramatically reduce TCO while delivering comparable performance and scalability, as well as leading-edge availability and data-protection features. Those advantages are now being compounded further with the introduction of SQL Server 2012.

1 EXECUTIVE SUMMARY

Open architectures are now a viable option for mission-critical workloads. Decision makers are uniting behind the trend to replace legacy proprietary systems, and with good reason. Solutions built with Microsoft SQL Server* applications running on servers based on the latest Intel® Xeon® processors are a cost-effective option to deliver mission-critical scalable performance and advanced reliability. The high degree of co-engineering and collaboration between Microsoft and Intel that has gone into this solution stack pays off in unparalleled benefits to end customers.

This paper examines the factors that have made the combination of SQL Server and Intel Xeon processors so effective. It consists of the following main sections:

- **World-Class, Mission-Critical Solution Stack**. This section outlines the mission-critical features of the Intel Xeon processor E7 family and SQL Server 2008 R2, describing how they complement one another. Key security and manageability aspects of the solution stack are also described.
- **Demonstrating Performance and Scalability**. This section explores the performance and scalability wins that are possible using SQL Server 2008 R2 on the Intel Xeon processor E7 family and introduces tuning and configuration best practices to help enable optimal results.
- **Technologies and Expertise to Enable Migration**. This section introduces some of the resources that Microsoft and Intel provide to assist customers in migrating from proprietary architectures—ranging from technical libraries to automated migration tools.
- **Success Report: Temenos Group AG**. Headquartered in Geneva, Switzerland, Temenos Group AG provides banking software systems to customers worldwide. This case study shows how the company has benefitted from multiple generations of Intel Xeon processors and SQL Server.
- **A Look Ahead: Microsoft SQL Server 2012**. This section describes how the next generation of SQL Server will deliver improvements across functional areas that make it even better suited to mission-critical deployments of all types.

Contents

2 Overview

Enormous data stores continue to rise in importance as core assets of companies across industry verticals. The organizations that own that data must make smart strategic choices to ensure cost efficiency, performance, scalability, and reliability for applications. The evolution of large-scale data solutions traces its history back to mainframes and, later, midframe-scale machines. These were once the only viable platforms for very large collections of critical data, such as that used by the financial-services industry, government infrastructure, and clinical medicine. As technology advanced, smaller-scale proprietary hardware architectures such as RISC emerged to take on many of those tasks, providing significant cost savings.

Today, that progression continues with the movement of mission-critical applications from proprietary environments to the latest generations of powerful, open, standards-based hardware and software. The sophisticated technologies that underlie this shift offer further cost benefits to the enterprise, as exemplified by solutions based on Microsoft SQL Server running on servers based on the Intel Xeon processor, a highly optimized combination that draws from decades of close collaboration between Intel and Microsoft. Co-engineering begins at the very early stages of the life cycles of both Microsoft software products and Intel® hardware platforms. By the time these products are introduced to the public, they benefit from a mature relationship based on intertwined development and optimization.

In addition to the ability of these systems to deliver comparable performance, scalability, and reliability at lower cost than legacy proprietary systems, they offer additional benefits based on the following advantages:

- **Unparalleled software ecosystem**. Simple, dependable, and robust integration with other Microsoft Server products makes SQL Server an excellent choice as part of an integrated, flexible data center solution. Moreover, the unparalleled x86 software ecosystem provides tremendous breadth of applications and extraordinary device-driver support.
- **Broad availability of systems expertise**. Finding highly qualified database administrators (DBAs), network architects, and systems administrators is far simpler with these open systems because the technology is widely known and professional certifications are widespread. Broad applicability also helps companies avoid expensive consulting fees often associated with proprietary systems.
- **Choice of hardware manufacturers**. Open standards provide for a variety of original equipment manufacturers for servers and other hardware components. In particular, high-volume manufacturing of Intel® platform building blocks drives down costs, and competition among system makers helps ensure cost effectiveness for end customers.

Wise organizations are harnessing enterprise data with SQL Server and Intel Xeon processors, and this strong, fast data platform continues to provide them with game-changing scalability and performance, advanced reliability, and dramatic TCO reductions. As a result, enterprise users are seeing benefits such as the ability to gain deep business insight from business intelligence (BI) capabilities, leading to better business decisions that can ultimately help the business run better and faster as it seeks to maximize competitiveness and profitability.

3 World-Class, Mission-Critical Solution Stack

Mission-critical database implementations based on open standards begin with industry-leading solution building blocks: the Intel Xeon processor E7 family and SQL Server 2008 R2. Both are extraordinary offerings on their own, and co-engineering between the companies makes the solution stack even greater than the sum of its parts.

3.1 Intel Xeon Processor E7 Family

As the latest offering in Intel's line of processors for the highly scalable market segment (four or more processor per system), the Intel Xeon processor E7 family delivers uncompromising scalable-performance headroom and advanced reliability for the mission-critical enterprise. This platform is ideally suited to the IT challenges of managing and keeping data secure. These top-of-the-line processors deliver excellent results for most data-demanding workloads, adapting quickly to changes in short-term business demands while addressing requirements for longer-term business growth.

3.1.1 Scalable Performance Features

The Intel Xeon processor E7 family delivers massive performance headroom that begins with as many as 10 execution cores per socket, which with Intel® Hyper-Threading Technology enabled can handle as many as 20 software threads simultaneously. That capability translates to as many as 80 threads at the same time in a relatively modest four-processor system. A broad complement of scalable performance features completes the picture, creating an excellent deployment environment for demanding business workloads such as those based on SQL Server 2008 R2:

- **30-megabyte last level cache** keeps a large pool of data ready—close to the execution engine—minimizing the need for resource-intensive lookups to system memory.
- **Large memory capacity**, including support for 32-gigabyte DDR3 DIMMs (as much as 2 terabytes per four-socket system) dramatically accelerates memory-bound database applications.
- **Intel® QuickPath Interconnects** provide high-speed, point-to-point links that speed up data transfers by connecting memory, processor cores, the I/O hub, and other Intel® processors.
- **Intel® Turbo Boost Technology** automatically allows processor cores to run faster than the base operating frequency if operating below power, current, and temperature specification limits.

3.1.2 Advanced Reliability Features: Mission-Critical RAS

The Intel Xeon processor E7 family offers mission-critical reliability, security, and availability (RAS) features, including self-healing features that allow for continued operation in case of component failures. These features also give IT shops the tools to maintain systems and reduce the amount of downtime.

SQL Server 2008 R2 implementations benefit from the ability of Windows Server* 2008 R2 to take excellent advantage of the mission-critical RAS features of the Intel Xeon processor E7 family. Advanced reliability and security capabilities work to maintain data integrity and maximize the availability of mission-critical applications. Key hardware-platform features in this category that particularly benefit mission-critical deployments of SQL Server 2008 R2 include the following:

- **Machine Check Architecture Recovery** works with Windows Server 2008 R2 to recover from uncorrectable memory errors, which might have caused a system crash in prior generations.
- **Double Data Device Correction** (DDDC) extends reliability by enabling recovery from two simultaneous DRAM device failures, helping maximize uptime.
- **Partial Memory Mirroring** enables flexible, effective, and cost-efficient memory mirroring of critical areas instead of utilizing all of the memory, reducing server energy demands while protecting key data.
- **Memory Predictive Failure Analysis** enables problematic components to be identified and replaced before they fail, preventing downtime or uncorrectable errors.

For more about the mission-critical features of the Intel Xeon processor E7 family, visit www.intel.com/itcenter/topics/missioncritical.

3.2 Microsoft SQL Server 2008 R2

SQL Server 2008 R2 provides a complete set of technologies and tools built to support the mission-critical enterprise. Every aspect of the system is designed to deliver high value from information while maintaining low TCO. The environment is well optimized for the Intel Xeon processor E7 family, to provide high levels of performance, availability, and security, paving the way for businesses to gain pervasive insight with self-service BI.

3.2.1 Scalability Features

As an enterprise-focused solution, SQL Server 2008 R2 incorporates features that enhance scalability of the overall solution. These features are designed to ensure that as the levels of resources, such as processor cores and memory, increase, they are shared effectively among various parts of the workload, optimizing utilization and therefore scalability.

Partitioned Table Parallelism is a key capability—particularly in the context of deployments with the Intel Xeon processor E7 family—that helps enable businesses to get the most power possible from their system hardware. This innovation improves on earlier approaches in terms of the way queries utilize software threads (and by extension, processor execution cores).

For example, consider a data warehouse application that collects large amounts of historical data in fact tables that are partitioned by date. In previous versions of SQL Server, a query that touched multiple partitions used exactly one thread per partition, an inflexible approach that often limited scalability by failing to take optimal advantage of the large numbers of cores often available on large-scale server hardware. Partitioned Table Parallelism offers a more flexible approach, where queries can exercise more intelligent decisions around the number of software threads to use, regardless of the number of partitions a query touches.

Notably, Partitioned Table Parallelism is enabled by default on SQL Server 2008 R2, and it requires no manual tuning, configuration, or application code changes to deliver its benefit. By assigning the optimal number of threads to a given query, this feature can deliver higher performance when additional hardware resources are available. That capability translates into better scalability, since additional processor cores are able to have a greater impact on the overall query performance than in a system without Partitioned Table Parallelism.

Among the other features of SQL Server 2008 R2 that complement Partitioned Table Parallelism in enhancing scalability, two stand out as being particularly valuable:

- **Resource Governor** enables applications to control the amount of processor and memory resources that are assigned to a given part of a relational database workload. This capability helps prevent individual queries from consuming disproportionate amounts of resources, which could otherwise negatively affect scalability.
- **Analysis Services Enhanced Backup** provides for highly scalable backup services that handle databases over a terabyte in size. Therefore, rather than rely on raw file system copy utilities to back up large databases, customers can use the built-in backup subsystem that is integrated with the transactional system, which allows backup operations to be run in parallel with other operations.

To take advantage of these scalability features, no application changes are necessary—a core benefit. They just work, improving performance and scalability without placing additional requirements on the IT organization.

3.2.2 Performance Features

SQL Server 2008 R2 incorporates a high-performance query-processing engine that enables customers to generate fast response times from their enterprise database applications, a critical factor in mission-critical systems. At the heart of this capability is the evaluation of queries to generate optimal query execution plans, based on dynamically maintained and stored statistics about indexes, key selectivity, and data volumes.

This analysis has the intelligence to efficiently assign query workloads to the large-scale parallel resources available from servers based on the Intel processor E7 family. This effective utilization of parallel hardware resources helps deliver the high performance needed to remain responsive to user requests, even when they involve complex operations on very large data sets. Likewise, the query engine performs sophisticated predictions of the data pages that will be required for a given execution plan, dynamically caching data in advance of when it is needed, further enhancing performance.

SQL Server 2008 R2 also incorporates performance optimization and monitoring tools that enable DBAs and systems administrators to collect, analyze, and act on runtime data from the production database environment:

- **SQL Server Profiler** enables the capture of traces of events that occur during the execution of a typical application workload.
- **Database Engine Tuning Advisor** generates and implements recommendations for indexing and partitioning data, based on the traces created using SQL Server Profiler.
- **Performance Studio** provides an end-to-end performance-monitoring solution that includes an application programming interface, allowing administrators to control the environment and access data programmatically.

3.2.3 Mission-Critical Reliability Features

SQL Server 2008 R2 offers reliability technologies that complement the support Windows Server 2008 R2 offers for the Intel Xeon processor E7 family RAS features described above. Because business customers require 100-percent availability for many of their applications, these capabilities address the variety of factors that can lead to system downtime, including human error, hardware or software failure, planned maintenance outages, and natural disasters.

3.2.3.1 Availability Features

One of the most important issues concerning the mission-critical aspects of a database environment is failover and recovery in case of a hardware or software fault. SQL Server 2008 R2 helps address these factors with the following availability features:

- **Database Mirroring** automatically makes database changes to a secondary server that mirrors the primary one, enabling the secondary server to take over if a system failure occurs.
- **Failover Clustering**, provided by Windows Server 2008 R2, enables all a server's services (not just the database) to be restarted on another cluster node if a failure occurs.
- **Peer-to-Peer Replication** enables multiple databases to be replicated with one another, with each acting as a failover for the others, allowing local access from multiple sites.

- **Log Shipping** provides one or more warm standby servers (as opposed to the single server with database mirroring) that are periodically updated using log backups from the primary server.
- **Partial Database Availability** enables the undamaged part of a database to remain online and available, even if part of the database is damaged from isolated hardware or disk failures.
- **Backup and Restore Enhancements** compress backups to reduce their size, enabling access to portions of partially restored databases and allowing restore of individual pages from backup.

Availability features that help minimize planned downtime are also important. Planned outages can significantly interfere with day-to-day application availability. To address this issue, SQL Server 2008 R2 provides the following features:

- **Online Index Operations** allow data to remain available during operations such as creating, dropping, or rebuilding indexes.
- **Dynamic Configuration** supports hardware RAS features in the Intel Xeon processor E7 family for hot add of memory and processors, automatically using those new resources.
- **Fast Database Recovery** makes the database available during the undo part of the recovery process, with partial availability during restore operations, database page checksums, and backup media mirroring.

Even within the scope of normal operations, database environments must enhance availability. To help ensure users have access to necessary resources on an ongoing basis, SQL Server 2008 R2 provides the following features:

- **Optimized Locking** uses snapshot isolation to prevent writers from blocking readers and readers from blocking writers, which helps to increase application availability.
- **Resource Governor** proactively assigns priorities to different workloads based on logins, application, and other factors, which helps prevent resource contention.
- **Table Partitioning and Index Partitioning** break large tables into smaller, more manageable units that can be accessed independently of each other, which helps improve the tables' availability and manageability.

3.2.3.2 Data Protection Features

In addition to system availability, it is equally important for mission-critical implementations to avoid data loss and integrity. SQL Server 2008 provides a number of features specifically for data protection, including the following:

- **Synchronous Database Mirroring** applies changes from the primary server to the secondary one in real time, ensuring the presence of exactly matching data if failover occurs.
- **Automatic Recovery of Corrupt Pages** extends the protection offered by database mirroring to individual pages of data, seamlessly retrieving corrupted pages if necessary.
- **Log Shipping to Reverse Data Changes** intentionally introduces a delay before transferring changes from the master server to the secondary one, allowing user error to be reversed.
- **Checksum on Data Pages** compares values written to disk with values that are subsequently read; if they don't match, the relevant page can be restored from a partner server. Checksums allow multiple retries, so they can also be used to resolve transient host bus adapter errors, even if a secondary server isn't configured.
- **Data Protection Manager** continuously synchronizes SQL Server database changes to a separate server that provides disk-based recovery and tape-based archival storage.

3.2.4 Security Features

Enterprise-class security features implemented in SQL Server 2008 R2 help reduce the vulnerabilities to mission-critical resources and streamline regulatory compliance for organizations. For details on certifications and compliance of SQL Server 2008 R2, see http://download.microsoft.com/documents/France/Serveur/2011/sql/SQLServer2008-compliance-and-certifications.pdf. The following features are of particular note in this area:

- **Transparent Data Encryption (TDE)** enables encryption of the entire database, without requiring application changes, removal of functionality, or significant performance degradation.
- **All Actions Audited** allows IT organizations to analyze data usage patterns, including auditing not only changes to data but also which users are reading what data.
- **Policy-Based Management** provides for policies that can control many different aspects of SQL Server, on a single server or groups of servers, to help manage compliance.

3.2.5 Manageability Features

Capabilities for management built into SQL Server 2008 R2 simplify the implementation and management of high-availability solutions and reduce the need for third-party software and specialized hardware. They also optimize the efficiency with which administrators can investigate, monitor, and recover damaged data.

- **Failover Clustering**, described above, benefits from simplified setup and management capabilities, including a cluster management snap-in, Microsoft PowerShell*, read-only APIs, network prioritization, and enhanced security.
- **PowerShell**, a powerful scripting shell, gives administrators the ability to build robust, sophisticated scripts to automate server administration.

4 Demonstrating Performance and Scalability

Scalable performance is a key differentiator for mission-critical database solutions. These types of environments must meet targets for query response and latency, and be able to take advantage of additional hardware resources as they are added.

4.1 Use of the Hammerora Load Testing Tool

Because the various database applications that organizations use present unique challenges and requirements, the ability to conduct scalable-performance testing in one's own environment is vital. One approach to that "self-serve" testing modality is to use the Hammerora database load testing tool, which is offered under open-source (GPL) license at SourceForge. This lightweight tool enables database performance comparisons in the absence of official data. While Hammerora includes workloads based on industry standard TPC specifications, it does not provide official results. Nevertheless, the tool predicts relative (not absolute) performance results that are useful in areas such as determining the impact of specific hardware features or other technologies within a database environment.

Hammerora provides a wizard-based installation on Windows Server 2008 R2 and offers scalable, automated, and GUI-driven operations. A built-in SQL Server test interface uses the ODBC (Open Database Connectivity) interface to access the database management system. For RISC migration projects, Hammerora can test the scalability of specific workloads under SQL Server, as well as absolute performance. By testing the pre-migration environment alongside the post-migration one, individual end customers can directly compare results across both environments. In particular, achieving the following objectives is a straightforward proposition using the Hammerora test environment:

- **Investigate SQL Server performance and scalability** in the context of migrating mission-critical databases from the RISC environment.
- **Identify optimal tuning and configuration** of SQL Server and the underlying Windows Server 2008 R2 OS on the Intel Xeon processor E7 series for the particular application workload under consideration.

For more information on Hammerora testing, see http://hammerora.sourceforge.net/ and www.sqlservercentral.com/blogs/aschenbrenner/2011/11/23/running-a-tpc_2D00_c-workload-on-sql-server/.

4.2 Performance and Scalability Test Environment

To demonstrate the performance and scalability of SQL Server 2008 on two-way and four-way servers based on the Intel Xeon processor, Steve Shaw of Intel in the UK led a test team that used Hammerora's ability to simulate large, processor-intensive OLTP-based workloads. The test environment is shown in Figure 1.

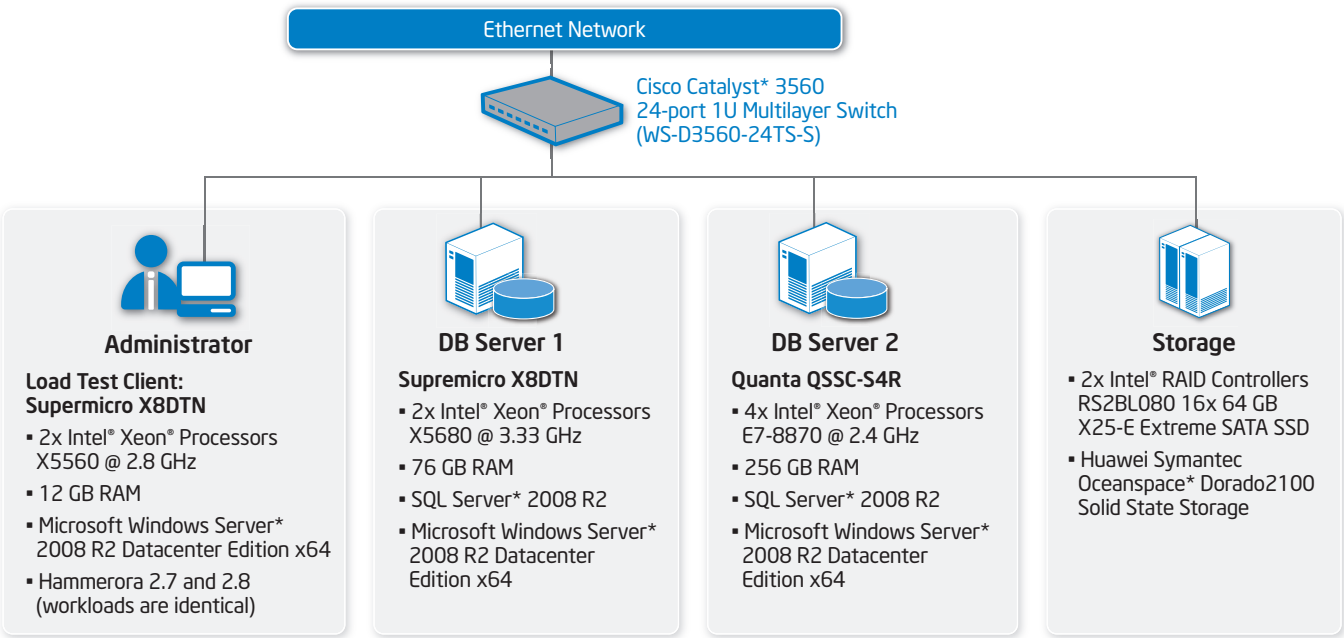

Figure 1. Performance and scalability test environment.

The test environment was relatively simple, with a Hammerora test client, two database servers (one each based on the Intel Xeon processor E7 family and the Intel® Xeon® processor 5600 series), and a storage array networked using a Cisco Catalyst* 3560 switch.

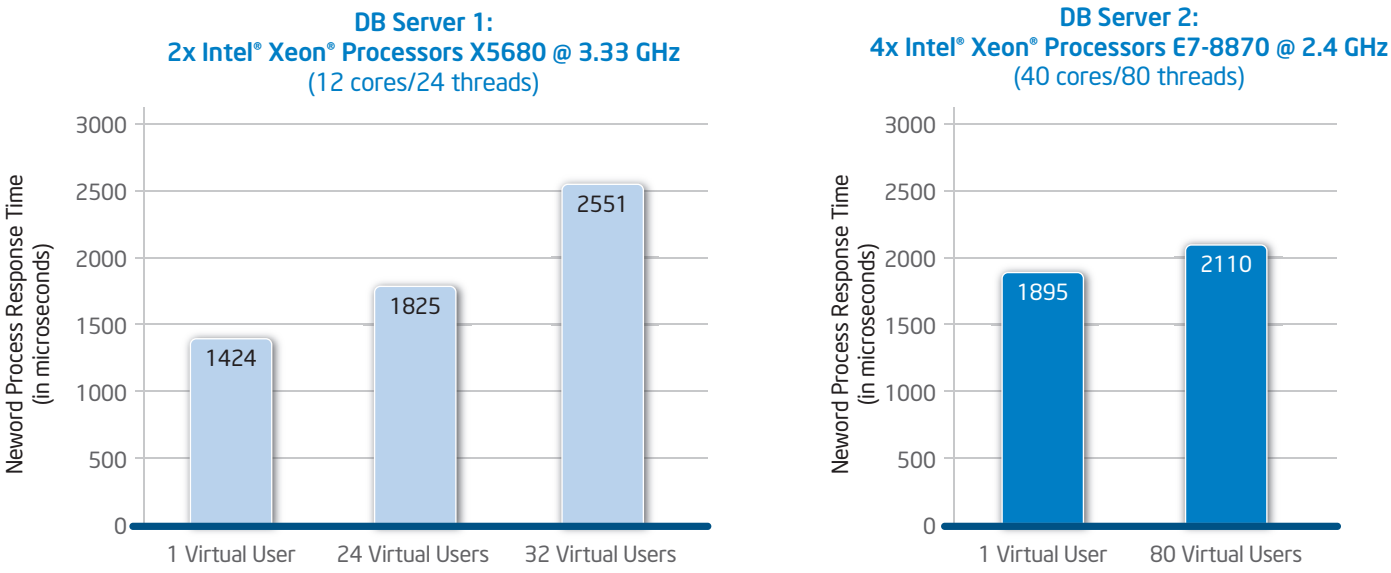

Figure 2. Hammerora test results for Microsoft SQL Server* 2008 R2.

Early observations during testing indicated that using Intel® Solid-State Drives X25-E for transaction logs provided superior performance, compared to conventional magnetic drives. Additionally, the Huawei Symantec Oceanspace* Dorado2100 solid-state storage array shown in Figure 1 was added to the test environment for the data area, resulting in a storage configuration residing entirely on solid-state disks. Table partitioning was also identified as a worthwhile way to enhance performance, particularly on the four-socket database server based on the Intel Xeon processor E7 family.

4.3 Performance Test Results

To gauge performance capabilities of SQL Server 2008 R2 on the Intel Xeon processor, the test team configured virtual users with highly intensive workloads to stress the systems and emphasize the results. Response times for the NEWORD process (i.e., the time the system takes to perform a single New Order transaction) for various numbers of users are given for both the Intel Xeon processor 5600 series and the Intel Xeon processor E7 family in Figure 2. These results quantify a key aspect of the simulated user experience.

Of significance among the various test systems results is that response times are closely correlated with processor frequency, when the number of virtual users is relatively small. For example, consider the NEWORD process result for one virtual user: The 1,424 microsecond response time on DB Server 1 is 1.33x faster than the 1,895 microsecond response time on DB Server 2, which correlates to the 3.33-GHz processor frequency on DB Server 1 being 1.38x greater than the 2.4-GHz processor frequency on DB Server 2. Note that the ability of Intel Turbo Boost Technology to increase processor frequency on demand has the potential to substantially improve performance for these relatively small numbers of users.

This effect predominates in cases where the number of virtual users is equal to or less than the number of hardware threads supported by the server; in fact, response time for 24 virtual users on DB Server 1 is faster than that for one virtual user on DB Server 2. On the other hand, response times clearly benefit from increased core counts to prevent the number of virtual users from exceeding the number of available hardware threads. For example, note that the response times for 80 virtual users on DB Server 2 (which provides 80 hardware threads) are dramatically better than the response times for just 32 threads on DB Server 1. These results confirm that SQL Server 2008 R2 benefits significantly from the high core counts available from the Intel Xeon processor E7 family.

4.4 Scalability Test Results

Related to the effect noted above of the benefits of higher core counts, scalability of a Hammerora workload with SQL Server 2008 R2 is shown in Figure 3.

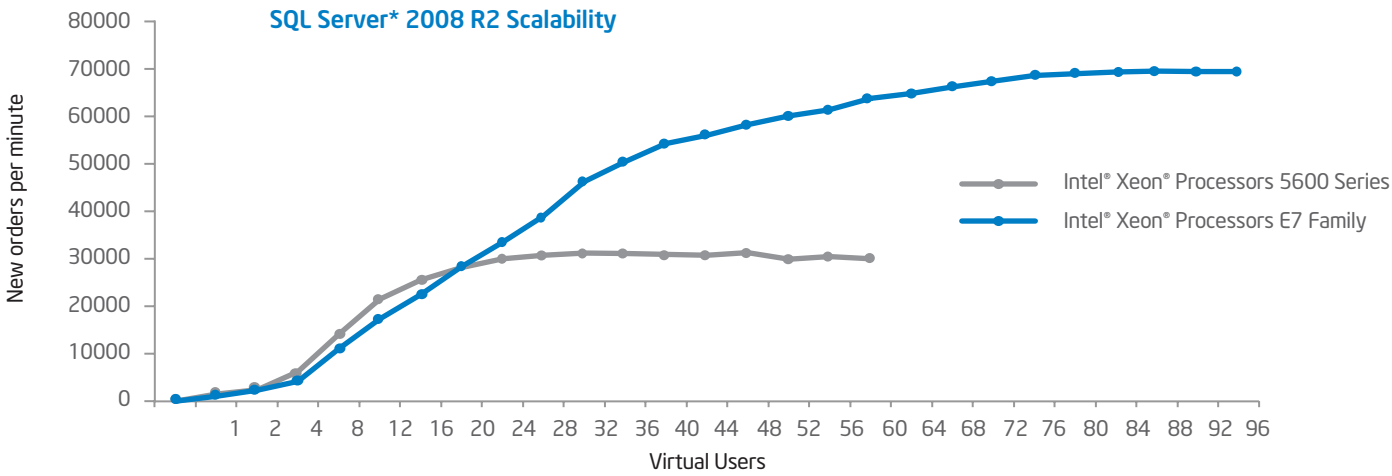

Figure 3. Scalability of Microsoft SQL Server* 2008 R2 across the Intel® Xeon® processor E7 family and Intel® Xeon® processor 5600 series.

Peak transactional throughput (measured in new orders per minute) is 313,562 for the two-way server based on the Intel Xeon processor X5680 and 695,389 for the four-way server based on the Intel Xeon processor E7-8870. Thus, the ratio of throughput for the four-way server divided by that for the two way server is 2.22.

5 Technologies and Expertise to Enable Migration

Migrating from legacy proprietary architectures such as RISC to open, standards-based ones based on SQL Server and Intel Xeon processors offers substantial advantages. Among them, flexibility and cost-effectiveness are compelling enough that they have generated widespread interest in the past several years, culminating in a growing exodus away from RISC-based databases.

As described throughout this paper, this combination of Microsoft and Intel technologies creates a solution that is well suited to the technical needs of mission-critical deployments, while also providing significant business advantages. Whereas RISC-based database vendors typically attempt to lock customers into a rigid, end-to-end framework that ties them to a specific hardware vendor (and high equipment cost), the Microsoft and Intel solution allows for a broad ecosystem of equipment providers. The resulting open competition among server manufacturers helps drive down equipment costs and accommodate individual needs for server features, scale, and capabilities.

Moreover, in comparison to other open systems, SQL Server on Intel Xeon processors offers superior cost benefits while delivering a state-of-the-art, mission-critical database environment. The configuration and management of SQL Server-based solutions exemplify a simple path to excellent results, right out of the box. Thus, in addition to being relatively easy and fast for a DBA to meet performance targets, doing so also requires less specialized expertise, which also contributes to lower operational costs. To streamline the migration process, the following resources are available to end customers:

- **Microsoft SQL Server Migration Assistant** is a free tool that simplifies migrating data from other database environments to SQL Server, converting the database objects to SQL Server database objects, loading those objects into SQL Server, migrating data to SQL Server, and then validating the migration of code and data.
- **Services from Microsoft, Intel, and the global partner ecosystems** help customers make informed decisions based on deep analysis, then help plan and execute the migration, before following up with ongoing support and training that helps ensure long-term, continuing success in the new environment.
- **Extensive self-serve, online resources** capture everything from migration benefits and planning to assistance in the migration itself. See www.microsoft.com/sqlserver/en/us/product-info/migration.aspx and www.inteldatacentermigration.com to get started with the best practices captured by experts at Microsoft and Intel.

6 Success Report: Temenos Group AG

To demonstrate the ability of SQL Server running on Intel Xeon processor-based servers to support mission-critical workloads, Intel and Microsoft worked with Temenos, a global financial-services software provider. Headquartered in Geneva, Switzerland, Temenos serves more than 1,500 customers in more than 125 countries around the world. The company's T24 product is a fully integrated, modular core banking solution that covers a broad spectrum of functional requirements for financial institutions.

Testing with T24 workloads was conducted with two generations of hardware and software technology: first with SQL Server 2008 R2 on Intel Xeon processors 7500 series and then with SQL Server 2012 on the Intel Xeon processor E7 family. Each of those sets of testing showed record-breaking benchmark results, including the following average interest accrual and capitalizations per second during close-of-business testing:

- **SQL Server 2008 R2**: 5,203 transactions per second[1]
- **SQL Server 2012**: 10,008 transactions per second[2]

These results make it clear that the combination of T24, SQL Server, and Intel Xeon processors is a viable choice for the mission-critical workloads of the world's largest banks. More detailed analysis of the testing is provided below.

6.1 Temenos Highwater Benchmark Test Methodology for Performance and Scalability

Temenos defined a set of standard, real-world banking transactions for use in testing, which it referred to as the Highwater Benchmark. The set of transactions was designed to represent typical processing loads at a large Tier-1 retail bank.

Primary testing scenarios included the following:

- **Online business-transaction testing** represented activity during regular business hours, using nine different types of transactions, such as deposits, withdrawals, and ATM transactions.
- **End-of-day batch-process testing** represented account reconciliation and similar tasks that an operating bank would typically conduct each day after the close of business.

For each of those types of testing and for each of the versions of SQL Server, Temenos set target levels for performance, processor utilization, and scalability, as captured in the results section below. Those target levels were set with the goal of simulating the needs of a typical large retail bank while providing for high levels of hardware efficiency and the ability to add capacity to the solution as hardware and software technology advance and the business grows.

6.2 Temenos Test Results for SQL Server 2008 R2 and SQL Server 2012

The performance, processor utilization, and scalability levels targeted by testing, as well as the actual levels measured, are shown in Table 1.

The targets were based on the needs of existing and prospective T24 customers for SQL Server 2008 R2, with the scope of potential workloads increased to reflect the added capabilities of SQL Server 2012 and its potential to increase the size of supported bank operations:

- **Online transaction throughput targets** were based on approximately 22 million and 50 transactions per eight-hour day (with a peak-hour load of 50 percent of all daily transactions), for SQL Server 2008 R2 and SQL Server 2012, respectively.

Table 1. Temenos T24 Highwater Benchmark testing targets and results

		SQL SERVER* 2008 R2 ON THE INTEL® XEON® PROCESSOR 7500 SERIES[1]	SQL SERVER* 2012 ON THE INTEL® XEON® PROCESSOR E7 FAMILY[2]
Online Transactions	Target	At least 3,000 transactions/second	At least 7,000 transactions/second
	Measured Result	✓ 3,437 transactions/second	✓ 11,592 transactions/second
Batch Processing	Target	No more than 2 hours	–
	Measured Result	✓ 1 hour 20 minutes	✓ 41 minutes 38 seconds
Processor Utilization	Target	No more than 75% utilization	No more than 75% utilization
	Measured Result	✓ No more than 70% utilization	✓ No more than 75% utilization
Scalability	Target	Near-linear scaling	Near-linear scaling
	Measured Result	✓ 95% scaling	✓ 95% scaling

- **Batch-processing completion-time targets** were based on the capability to run end-of-day batch processes for 25 million accounts in a suitable timeframe.
- **Processor-utilization targets** were set for the database server, to preserve performance headroom to accommodate foreseeable peak-usage requirements.
- **Scalability targets** were set to allow for effective use of server hardware as the number of agents increased.

Testing met all of the target levels, as summarized in Table 1. Results for both SQL Server 2008 R2 and SQL Server 2012 are impressive, and together, they show pronounced progress with the technology refresh from the earlier to the later generations of server hardware and database software. Likewise, customers that implement software stacks based on SQL Server and Intel Xeon processors may expect continuing improvements that drive ongoing success as their environments mature and data sets place ever-deepening demands on them.

These results unequivocally demonstrate the ability of SQL Server and standards-based servers based on the Intel Xeon processor to support large-scale, mission-critical environments such as the transactional workloads of large-scale banking institutions. The cost-effectiveness of these solution stacks emphasize the strategic imperative of migrating away from RISC and other legacy proprietary architectures.

7 A Look Ahead: Microsoft SQL Server 2012

With the introduction of SQL Server 2012, the mission-critical enterprise has an even more compelling set of database choices. This offering builds on the advantages of SQL Server 2008 R2, providing even greater performance, scalability, reliability, security, and manageability. This section provides an introduction to the key features of the platform, demonstrating the value this new generation of SQL Server offers. Core features and benefits are summarized in Figure 4.

HIGH AVAILABILITY	SCALIBILITY & PERFORMANCE	SECURITY & MANAGEABILITY	BEYOND RELATIONAL	BUSINESS INTELLIGENCE	WEB & BREADTH, AND EIM
HA for Microsoft StreamInsight*	Up to 15K partions/table	Contained datbase authentication	Microsoft project "Juneau"	Unifed semantic model	PHP driver
Reliable integrated failover detection	Column stores index, "Apollo"	User-defined server roles	Microsoft Win32* access to database files	Crescent	Lacal DB runtime
Applicatoin-centric failover	Fast FILESTREAM	Distributed replay	File Table	In-memory BI for corporate	UTF-16
Multiple, readable secondaries	Fast full-test search	Audit enhancements	Semantic search platform	Alerting	Paging results sets
Online poerations	Fast spatial perfomance	Management pack for HA	Full globle spatial support	Sysprep forAS	JDBC 4.0 driver
Microsoft SQL Server *AlwaysOn	DBC and OLTP appliances/RAs	Backup secondaries	DAC enhancements	PowerPivot enhancements	Support for ARM processors
Windows Server* core support		Default schema for Windows group	ODBC for Linux*	Reporting as SharePoint shared service	MDS add-in for Excel
					Data quality
		Active Directory with Microsoft SharePoint* for SSRS	Hybrid apps with Microsoft SQL Azure*		Enhanced MDS
					SSIS server

Figure 4. Overview of Microsoft SQL Server* 2012 capabilities. Source: Microsoft

7.1 Performance and Scalability Features

SQL Server 2012 drives up performance and scalability dramatically, relative to the already excellent results available from SQL Server 2008 R2. One feature that has garnered particular excitement throughout the industry is the new ColumnStore Index. This approach stores each column in a separate set of disk pages, instead of storing multiple rows per page. Together with enhanced query-processing features, this approach allows for dramatically accelerated query performance, due to the following factors:

- **Less data is fetched from disk**, because only the columns needed to solve a query are retrieved (often fewer than 15 percent of the columns in a fact table).
- **Higher compression rates are possible**, because greater redundancy typically exists within columns than within rows.
- **Buffer hit rates are improved**, because of both the higher data-compression rates and the tendency for the most frequently accessed parts of commonly used columns to be retained in memory.

In addition to ColumnStore Index, SQL Server 2012 incorporates a number of other features designed to improve the performance of database-driven enterprise applications. For example, Active Secondary, which is an aspect of AlwaysOn Availability Groups (discussed below), enables secondary instances to run reporting queries and backup operations, improving resource utilization by putting hardware to use that would otherwise be idle. Active Secondary. PowerView and PowerPivot enable rapid data discovery for BI implementations using browser-based visualization to produce snapshots that can then be exported to Microsoft PowerPoint*, where the data is presented in its live, dynamically updated form.

SQL Server 2012's forward-looking architecture is built to scale on demand from the data center to the cloud, offering fast time to solution with appliances and cloud offerings, optimized productivity that supports "write once, run anywhere" functionality, and breakthrough data extensibility for the cloud. The product also offers a comprehensive set of data warehousing solutions, including software-only solutions, hardware and software reference architectures, and integrated hardware and software appliances. These solutions are suited to implementations that range from under five terabytes in size, up to tens or hundreds of terabytes.

7.2 Mission-Critical Reliability Features

Since SQL Server 2012 is designed specifically with the mission-critical enterprise in mind, a substantial amount of effort has been placed on reliability features. Chief among these is SQL Server AlwaysOn, which dramatically simplifies the process of deploying and managing high-availability solutions. This set of features and capabilities provides integrated, flexible, cost-efficient high-availability and disaster-recovery solutions with AlwaysOn Availability Groups, an integrated set of options to configure automatic and manual failover, up to four secondaries and two synchronous secondaries, fast application failover, and automatic page repair. Other capabilities built into SQL Server AlwaysOn include:

- **Failover Cluster Instances**, which enable failover across multiple data center sites for faster, more complete recovery.
- **Database Recovery Advisory**, which provides a visual timeline of the backup chain to enable intelligent point-in-time recovery.
- **Peer-to-Peer Replication**, which allows the configuration of applications to fail over to peers if a failure occurs, while detecting potential conflicts before they happen and enabling dynamic node addition.

SQL Server Integration Services helps ensure data confidence with an easy-to-use data integration tool designed to deliver integration, cleansing, and management of data. It provides capabilities that automate tasks, increase efficiency, and improve productivity related to information management efforts. As a result, information quality is improved while reducing risk, from design through source control.

7.3 Security and Manageability Features

SQL Server 2012 helps developers protect data with built-in encryption capabilities that protect confidential information without requiring application changes. In particular, SQL Server 2012 has the ability to create certificates from bytes, and it benefits from dramatically improved encryption support. These capabilities enable end customers to take advantage of a built-in cryptography hierarchy, encrypt data transparently, employ Extensible Key Management, and sign code modules. SQL Server 2012 also helps secure end-user data analytics with built-in IT controls, including new SharePoint* and Active Directory* security models for end-user reports published and shared in SharePoint.

8 Conclusion

Microsoft SQL Server and Intel Xeon processors offer a compelling migration target away from proprietary legacy architectures such as RISC. The outstanding performance, scalability, and mission-critical reliability of SQL Server 2008 R2 are being compounded further in SQL Server 2012, offering enterprises across industries with a more cost-effective, flexible approach that what they may be using today.

As each generation of Intel Xeon processors ratchets up the gains of its predecessors in terms of performance, scalability, reliability, and security, those advances make the switch to open architectures an even clearer choice. As the industry continues to transition to Microsoft and Intel solution stacks, the cost of doing business looks more favorable, even as the business results speak for themselves.

As a strategic imperative, considering database migration from proprietary architectures to SQL Server on Intel Xeon processors is now a clearer win than ever before.

For more information on the Intel® Xeon® Processor E7 family, visit
www.intel.com/xeon

For more information on collaboration between Microsoft and Intel, visit:
www.intelalliance.com/microsoft/enterprise-server.aspx

For more information on SQL Server 2012, visit
www.microsoft.com/sqlserver/en/us/future-editions.aspx

[1] "Benchmark Results for Temenos T24 with SQL Server 2008 R2 on Intel-based NEC Servers."
www.intelalliance.com/microsoft/Data/Sites/1/Article/Benchmark-Results-for-Temenos-T24-with-SQL-Server-2008-R2-on-Intel-based-NEC-Servers.pdf (PDF)

[2] "Benchmark Results: TEMENOS T24 Running on Microsoft SQL Server 2012."
http://download.microsoft.com/documents/uk/sqlserver/techdocs/Temenos_Solution_Brief_final_with_XIO.pdf (PDF)

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