Databases lie at the heart of mission-critical business infrastructure. Data must be quickly accessible at all times to keep applications responsive, customers happy, revenue flowing, and users productive. Yet database service levels are increasingly difficult to maintain as the velocity, variety, and volume of data continues to grow at unprecedented rates. Many businesses are finding that traditional mainframe and UNIX/RISC architectures are too costly and inflexible to keep pace with growing requirements. They need more scalable and adaptable database solutions and better cost models. They also need to maintain the highest levels of performance and availability.

Microsoft SQL Server 2012*, Windows Server 2012*, and servers based on the Intel® Xeon® processor E7 family offer a solution to these growing challenges: an enterprise-class database management platform designed to support mission-critical requirements at lower cost and with greater flexibility than traditional, proprietary solutions (see the sidebar, A Powerful Platform for Enterprise Data). Self-monitoring and self-healing capabilities are integrated throughout the hardware and software stack to provide robust high availability for each individual server. Fast, automated failover across LANs and WANs extends this inherent resilience to enable continuous data access for mission-critical applications.
Tight Reliability, Availability, and Serviceability (RAS)
Integration throughout the Solution Stack

The Intel Xeon processor E7 family is designed specifically for mission-critical computing environments. It contains a wide range of features to prevent, detect, correct, and contain the kinds of errors that can lead to system crashes in less resilient processors and platforms.

Leading server manufacturers build on this foundation to deliver robust server configurations designed for today’s most demanding computing environments. Redundant, hot-replaceable components and advanced management capabilities help IT organizations keep systems up and running more reliably. Many vendors also offer mission-critical service and support options with fast response times and a single point of contact for both hardware and software issues.

Robust Error Prevention and Correction

Memory errors are one of the most common causes of system downtime and they occur in every computing platform. The Intel Xeon processor E7 family employs a number of strategies that help to keep errors to a minimum.

- **Hardened circuits.** Most errors are caused by alpha particles and similar micro-events that change the logic state of a silicon latch. The Intel Xeon processor E7 family is built using materials and circuit designs that maintain their logic states more reliably following such events.

- **Memory thermal throttling.** Overheating of memory components can lead to memory errors and accelerate component failure. The Intel Xeon processor E7 family monitors memory elements and reduces the frequency of commands when necessary to help keep temperatures within rated values. This feature is especially valuable in today’s large-memory system configurations, since errors tend to be roughly proportional to the amount of memory in the system.

- **Rigorous validation and testing.** All Intel components undergo extensive quality testing to ensure high reliability. Validation criteria are even more demanding for the Intel Xeon processor E7 family to help deliver mission-critical reliability.

The Intel Xeon processor E7 family also incorporates self-monitoring and self-healing mechanisms throughout the platform to automatically detect and correct single and multi-bit errors and to maintain operation in the event of certain memory or I/O link failures.

Automatic Recovery from Uncorrectable Errors

Occasionally, an error occurs that cannot be corrected automatically by the mechanisms built into the hardware and firmware. In this case, the error is logged by Intel Machine Check Architecture (MCA) Recovery and passed through to the operating system, hypervisor, or enabled applications for more sophisticated remediation. MCA Recovery is fully supported in Windows Server 2012, Hyper-V, and SQL Server 2012 to provide coordinated error handling throughout the solution stack (Figure 1).

In many cases, Windows Server 2012 can automatically resolve an uncorrected error simply by taking the affected memory page offline and allocating a new page to the associated application. To do this, the page must be “free,” which means that any data in the page that needs to be preserved has already been saved to disk. When this is the case, the error is fixed in a way that is entirely transparent to the application.

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A POWERFUL PLATFORM FOR ENTERPRISE DATA

- **World-record performance.** Microsoft SQL Server 2012* and Windows Server 2012* running on the Intel® Xeon® processor E7 family hold the top score for online transaction processing (OLTP) based on the TPC-E* brokerage firm benchmark.

- **A high level of integrated functionality.** Microsoft SQL Server includes advanced support for online analytical processing (OLAP), data warehousing, and business intelligence (BI), without requiring costly add-ons that drive up total costs.

- **High-end scalability.** An eight-socket server based on the Intel Xeon processor E7 family provides up to 160 logical processors and 4 terabytes of memory. A single instance of SQL Server 2012 running on the Windows Server 2012 operating system can take full advantage of these resources and more. SQL Server 2012 and Intel Xeon processors offer even higher levels of scalability for enterprise data warehouses, enabling speed-of-thought analytics acting on hundreds of terabytes of data through massively parallel processing.

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Machine Check Architecture Recovery

**HOW IT WORKS**

![Machine Check Architecture Recovery Diagram](image-url)

HW Correctable Errors

SUPPORTED IN:
- Windows Server 2012
- Hyper-V
- SQL Server 2012

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Figure 1. The Intel Xeon processor E7 family includes Machine Check Architecture (MCA) Recovery, which is supported in SQL Server 2012, Windows Server 2012, and Hyper-V to enable higher availability through sophisticated error recovery.
If the page is not free, Windows Server 2012 can notify the application that owns the affected memory page (assuming the application is enabled for MCA Recovery). The application can then attempt to free the page. If the application is successful, the OS can then complete the corrective process by taking the page offline.

Comprehensive Software Support

SQL Server 2012 is the first major relational database to be enabled for MCA Recovery. It can be notified by the OS whenever an uncorrected error occurs within its allocated memory space. SQL Server 2012 can often free a corrupted page simply by reloading data from disk. As long as the associated memory page is clean (changes have already been saved to disk) and located within the SQL Server buffer pool, this corrective process can happen automatically, with no need for human intervention. Since the buffer pool tends to account for the majority of memory in most SQL Server deployments, this strategy provides excellent error coverage.

If the corrupted page lies outside of the SQL Server buffer pool or if changes on the page have not yet been written to disk, an alert can be triggered and the administrator can run diagnostics (using `sp_server_diagnostics`) to determine the best course of action.

Hyper-V is enabled for MCA Recovery, so the error correction processes described above also occur in virtualized servers. When an uncorrected error occurs within a Hyper-V virtual machine, the guest OS (assuming it is Windows Server 2012) can be enlisted to help correct the error and can enlist the aid of SQL Server 2012 or any other MCA Recovery-enabled application running in the virtual machine. If error recovery is successful, operation continues with no service interruption. If it is not, the error is contained within the affected virtual machine. That single virtual machine may have to be restarted, but the system, and all other virtual machines running on the system, will typically remain up and running.

The processes described above provide very robust error protection, containment, and recovery for SQL Server 2012 and Windows Server 2012 running on servers based on the Intel Xeon processor E7 family. There is still a small subset of uncorrected error conditions that could potentially force an immediate system reset, such as an error occurring within the OS kernel or within hypervisor resources. To protect against downtime in such cases, systems can be configured to enable automated or manual failover, as described later in this document.

Flexible Options for Even Higher Availability

Windows Server 2012 and the Intel Xeon processor E7 family support additional RAS features to increase single-server resiliency and data protection in mission-critical environments. Examples include:

- **Electronically isolated hardware partitioning.** Multiple workloads can be hosted on the same server while maintaining complete hardware and software isolation. This helps to reduce unplanned downtime, since hardware or software errors in one partition will have no impact on the other partitions. Planned downtime can also be reduced by performing maintenance on individual partitions without bringing down the entire server.

- **Full and partial memory mirroring.** Memory mirroring provides complete data redundancy for the most mission-critical applications. Support for partial mirroring allows IT organizations to apply mirroring to selected portions of memory, so they can balance the reliability benefits against the cost of additional memory.

- **Online component replacement.** Many vendors take advantage of advanced RAS features provided by the hardware and operating system to enable online replacement of failed or failing components. Depending on the vendor and server configuration, processors, memory, I/O hubs, fans, and power supplies can be replaced without bringing down the system. Spare components can be run in lockstep with the primary components, so the switchover to the new resources is transparent to applications.

Continuous Database Uptime through Fast, Automated Failover

The RAS features discussed so far help to keep individual servers and applications up and running. AlwaysOn Availability Groups in SQL Server 2012 support complete database replication with manual and automated failover across LANs and WANs—so even if a server does fail, service can continue with little or no disruption.

AlwaysOn Availability Groups combines a number of discrete capabilities in earlier versions of SQL Server into a single, integrated solution for high availability and disaster recovery that is easier to implement and more effective. Database mirroring, server clustering, log shipping, and automatic failover can be configured quickly using a setup wizard, monitored from a dashboard, and managed from a single interface. Windows PowerShell can be used to automate setup and management processes, which helps to ensure consistent configurations across the enterprise, while also reducing management overhead.
Using AlwaysOn Availability Groups, each primary database can be mirrored by up to four secondary databases (Figure 2). Storage can be shared among replicated databases, but shared storage is not required. Up to two of the secondary databases can be replicated synchronously, so they remain in complete lockstep with the primary database. Should the primary database fail, either one of the two secondaries can take over almost instantly with no loss of data. Secondary databases can also be replicated asynchronously. This strategy can be combined with log shipping to enable full database recovery.

IT organizations can combine synchronous and asynchronous replication as desired to meet their specific performance and recovery objectives. A key advantage of SQL Server 2012 is that secondary databases can now be used for queries, backups and other read-only tasks. This reduces the load on the primary database, which can help to improve performance across all workloads. It also improves overall utilization, so businesses can get higher value from their infrastructure investments.

SQL Server 2012 includes a number of additional new features that help to simplify and improve high availability and disaster recovery.

- **Faster, simpler manual recovery.** Recovery Advisor provides a visual timeline of the backup chain to enable faster, more accurate and more reliable point-in-time recovery.
- **Enhanced resiliency in virtual environments.** Hyper-V has been enhanced in Windows Server 2012 to provide better support for high availability and disaster recovery. Live migration of virtual machines is faster and simpler, live storage changes and upgrades.
- **Enhanced support for high availability and disaster recovery.** Hyper-V scalability has also been improved dramatically. Virtual machines can now be configured with up to 64 virtual processors and 1 terabyte of memory, so even very large databases can be virtualized with confidence.
- **Less planned downtime.** SQL Server 2012 can be deployed using the Windows Server Core role, which reduces the need for patching. SQL Server 2012 also provides enhanced support for online maintenance operations and for rolling patches and upgrades. Altogether, these enhancements can significantly reduce the need for planned downtime.
- **Simpler testing against realistic workloads.** SQL Server 2012 supports Distributed Replay, which allows IT staff to simulate complex, mission-critical workloads for testing. This can help to reduce potential errors to enable higher reliability after changes and upgrades.

**Extending High Availability throughout the Data Center**

Highly available databases provide an essential foundation for keeping applications up and running, but resilient storage, networking, and server infrastructure are also critical. The combination of Windows Server 2012 and Intel Xeon processor-based servers can help IT organizations address these needs more simply and cost-effectively than has been possible in the past.

**Highly Available Storage at Low Cost**

Until recently, providing storage for mission-critical applications required a storage area network (SAN), which can add to infrastructure costs. Server Messaging Block (SMB) 3.0 in Windows Server 2012 allows shared storage functionality to be layered on top of Intel Xeon processor-based file servers and low-cost disk arrays or “just-a-bunch-of-disks” (JBODs). Advanced capabilities, such as transparent storage failover, scale-out clustering, and multipathing (for network scalability and resilience) can be implemented simply and at low cost to support the requirements of demanding applications.

Figure 2. SQL Server 2012 includes AlwaysOn Availability Groups, which provides an integrated, unified solution for high availability and disaster recovery through fast manual and automated failover across LANs and WANs. Each primary database can be mirrored by up to four replicas, two of which can be synchronous.
A Scalable, Resilient Network

Windows Server 2012 supports network adapter teaming with 10 gigabit Intel® Ethernet Converged Network Adapters. It also allows multiple Dynamic Host Configuration Protocol (DHCP) servers to be configured for load balancing and automatic failover. With these enhancements, IT organizations can deploy scalable and fault-tolerant network connections and provide around-the-clock availability for core network services.

Protecting Applications through Automated Failover

Once databases, storage systems, and networks have been configured for high availability, Windows Server Failover Clustering, Hyper-V live migration, and Hyper-V Replica provide a simple, cost-effective solution for extending high availability and disaster recovery to applications through load balancing and automated failover. Windows Server 2012 supports up to 4,000 virtual machines and up to 32 nodes per failover cluster, and shared storage is no longer required to support live migration. This gives IT organizations a great deal of flexibility for establishing robust failover configurations while optimizing resource utilization throughout the data center.

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Conclusion

For many years, delivering uninterrupted data access for mission-critical applications has been a complex undertaking requiring costly, proprietary systems and failover solutions. Today, SQL Server 2012 and servers based on the Intel Xeon processor E7 family provide robust support for mission-critical enterprise databases. Advanced RAS capabilities are integrated throughout the hardware and software stack to prevent, detect, correct, and contain errors and to provide simple, automated database failover across LANs and WANs.

As the volume, velocity, and variety of data continues to grow, the performance, scalability, and cost efficiencies of the combined platform can help IT organizations grow and adapt their database solutions more easily, while maintaining the highest levels of uptime. In combination with Windows Server 2012 and the complete family of Intel Xeon processor-based servers, this mission-critical database platform also provides a flexible, cost-effective foundation for extending high availability and disaster recovery throughout the enterprise.

1 TPC-E® world record performance claim based on top ranked result of NEC Express5800/A1080a-E published using eight Intel® Xeon® processors E7-8870 (8P/160C/160T) scoring 4,614 tpsE @ $450.18USD available 4/2/2012 compared to all other results as of May 18, 2012. TPC, TPC-C, and tpcE are trademarks of the Transaction Processing Performance Council. For more information, please visit http://www.tpc.org/tpcc/default.asp.


3 MCA Recovery is supported in Hyper-V 3.0, which is included in Windows Server 2012. It is not supported in earlier versions of Hyper-V.

4 The SQL Server buffer pool is the portion of memory used to cache data as it is loaded from disk and modified.

5 Synchronous replication introduces some performance latency in the primary database, since the primary database cannot commit a transaction to disk until after the secondary database has done so. Because of this, it is typically not used across wide area networks.

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