White Paper

OLTP Reference Configuration Guidelines for Microsoft SQL Server 2008 R2 on Cisco UCS C-Series Rack-Mount Servers

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Introduction

The ability to conduct business transactions is central to business operations. The number and size of online transaction processing (OLTP) systems has grown exponentially due to a number of forces, including use of the Internet for conducting business, the need to track information for competitive reasons, and the need to retain and safeguard data for business analysis and to conform to regulatory requirements. Maintaining large amounts of data while maintaining rapid response times is a business-critical issue that puts pressure on IT departments to keep their OLTP infrastructure on the latest platforms. The pressure causing infrastructure change comes from a variety of sources including the following:

- Migration of complex applications from existing proprietary systems to industry-standard hardware and software
- Hardware refresh demands fueled by growing complexity and response-time requirements
- Consolidation of applications from multiple older servers to fewer, more powerful systems to simplify and reduce operating expenses (OpEx)
- New application deployments to address business growth and opportunities along with growing demands

Coupled with Microsoft SQL Server 2008 Release 2 (R2), Cisco® UCS rack-mount servers provide the breadth of products required to support a wide range of database configurations. As with any complex system, database infrastructure must be based on carefully selected components, the latest available technology, and proven best practices. To simplify platform selection an deployment, this document provides a set of guidelines and design principles for implementing small, medium, and large OLTP solutions using Microsoft SQL Server 2008 R2 on Cisco UCS C-Series Rack-Mount Servers.

The Cisco Unified Computing System™ is a single converged system that is entirely programmable through unified, model-based management to simplify and speed deployment of enterprise-class applications and services running in bare-metal,

virtualized, and cloud-computing environments. The alliance between Microsoft and Cisco uses the power of Cisco UCS C-Series Rack-Mount Servers to power the Microsoft software stack, which includes Microsoft Windows Server 2008 R2 and Microsoft SQL Server 2008 R2. Microsoft System Center tools help streamline and centralize management for both physical and virtual environments, including deployment, network optimization, and application services.

The reference configurations described in this document are intended for customers and partners who are evaluating, planning, or deploying OLTP applications such as enterprise resource planning (ERP), supply chain management (SCM), and web-based sales. The reference configurations provided can be viewed as best-practice building blocks. These tested and validated configurations can help reduce the chance of error and accelerate deployment while capitalizing on performance, scalability, and manageability. A predefined set of core components can also simplify system selection, sizing, and purchasing, while reducing time to deployment and helping ensure predictable performance.

Cisco UCS C-Series Rack-Mount Servers

Cisco UCS C-Series Rack-Mount Servers, based on Intel Xeon 5600 series processors, extend Cisco Unified Computing System innovations to an industry-standard rack-mount form factor. Many organizations prefer rack-mount servers because of the wide range of I/O options that are available in the form of PCI Express (PCIe) adapters. Cisco UCS C-Series servers support a variety of I/O options, including interfaces supported by Cisco as well as adapters from third parties.

These systems support a standards-based unified network fabric, Cisco VN-Link, and Cisco Extended Memory Technology. Designed to operate both in standalone environments and as part of the Cisco Unified Computing System, these servers enable organizations to deploy systems incrementally—using as many or as few servers as needed—on a schedule that best meets the organization's timing and budget. Figure 1 shows the current generation of Cisco UCS C-Series Rack-Mount Servers, and Table 1 provides a high-level comparison of features.

Figure 1: From Left to Right, Cisco UCS C200 High-Density, C460 High-Performance, C250 Extended-Memory, and C210 General-Purpose Servers

Table 1. Comparison of Cisco UCS C-Series Rack-Mount Server Features

	Cisco UCS C200 M1 and M2	Cisco UCS C210 M1 and M2	Cisco UCS C250 M1 and M2	Cisco UCS C460 M1
Ideal for	Production-level virtualization and mainstream data center workloads	Economical, high capacity, reliable, internal storage, file, storage, database, and content delivery	Demanding virtualization and large dataset workloads	High-performance, enterprise-critical, stand-alone applications and virtualized workloads
Maximum memory	192 GB	192 GB	384 GB	1 TB
Internal disk drive	Up to 4	Up to 16	Up to 8	Up to 12
Built-in RAID	0 and 1 (SATA only)	0 and 1 (5 SATA drives only)		
Optional RAID	0, 1, 5, 6, and 10	0, 1, 5, 6, 10, 50, and 60	0, 1, 5, 6, 10, 50, and 60	0, 1, 5, 6, 10, 50, and 60
Integrated networking	2X integrated Gigabit Ethernet; 10-Gbps unified fabric optional	2X integrated Gigabit Ethernet; 10 Gigabit unified fabric optional	4X integrated Gigabit Ethernet; 10-Gbps unified fabric optional	2X Gigabit Ethernet LAN-on-motherboard ports; 2X 10 Gigabit Ethernet ports
I/O via PCIe	Two, half-length, PCIe x8 slots: one full height and one low profile slot	Five, full-height, PCIe, x8 slots: two full length and three half length slots	Five PCIe slots: Three low-profile, half-length x8 slots; 2 full-height, half-length, x16 slots	Ten, full-height, PCIe slots: 4 half-length slots, 6 three-quarter length slots, 2 Gen 1 slots, 8 Gen 2 slots
Multicore Processors	Up to 2 Intel Xeon 5500 or 5600 Series	Up to 2 Intel Xeon 5500 or 5600 Series	Up to 2 Intel Xeon 5500 or 5600 Series	Up to 4 Intel Xeon 7500 Series

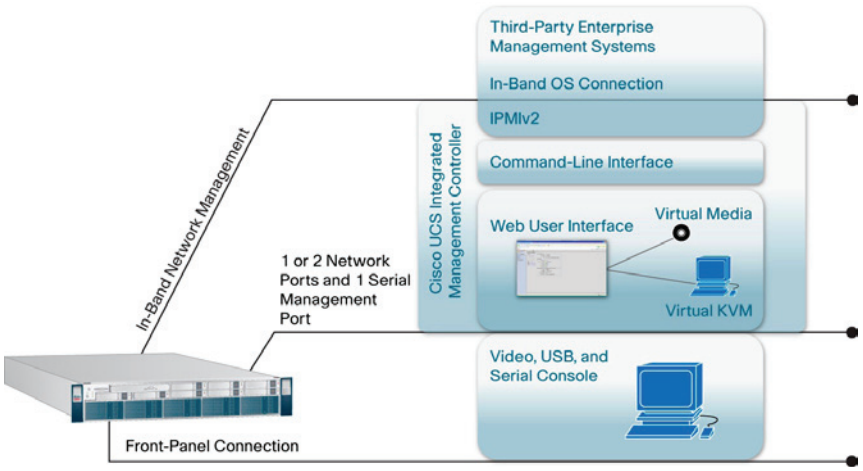

Figure 2. Cisco UCS C-Series Servers Offer Numerous Management Capabilities When Configured as Standalone Servers

When deployed as standalone servers in a heterogeneous environment, Cisco UCS C-Series servers can be managed similarly to any other server based on the x86 architecture. As shown in Figure 2, popular third-party enterprise management tools using OS-resident host agents work without modification. The Cisco UCS Integrated Management Controller (CIMC) gives administrators the tools they need to manually control server functions, including remote keyboard, video, and mouse (KVM); power on and off; and standard Simple Network Management Protocol (SNMP) traps for system monitoring. Video, USB, and serial console ports are available through a front-panel connection.

In addition to being deployed as standalone servers, Cisco UCS C-Series servers can be integrated into the Cisco Unified Computing System. This integration makes them part of a single cohesive system governed by unified, model-based management. The Cisco Unified Computing System offers exceptional flexibility in the use of resources. Cisco UCS C-Series servers can be configured in and out of the Cisco Unified Computing System as needed—providing significant investment protection—and they can operate within the Cisco Unified Computing System alongside Cisco UCS B-Series Blade Servers.

Microsoft SQL Server 2008

Microsoft SQL Server 2008 is a comprehensive database platform that offers the security, reliability, and scalability to support mission-critical applications. Responding to exceptional database growth, Microsoft SQL Server 2008 features a comprehensive set of services and tools to support any data type or device. Microsoft SQL Server 2008 also provides improved resource utilization, enhanced locking, and optimized data storage, yielding substantial performance and scalability. An innovative policy-based infrastructure simplifies data platform management, with improved performance monitoring and reporting tools in Microsoft Performance Studio. Microsoft SQL Server 2008 also provides high availability with improved

database mirroring and failover clustering, and it takes advantage of the inherent strengths of Microsoft Windows Server 2008.

Microsoft SQL Server 2008 provides a comprehensive data platform that supports the scalability, availability, security, and manageability needed for mission-critical OLTP applications.

- Scale and performance: With Microsoft SQL Server 2008, organizations can build database solutions with the performance and scalability capabilities that are required by the most demanding modern applications.
- High availability: Always-on technologies in Microsoft SQL Server 2008 provides high availability for databases, while reducing the management and performance overhead required for high-availability operation.
- Security: Microsoft SQL Server 2008 provides an enhanced secure data platform by encrypting valuable data, auditing changes to data and metadata, incorporating external cryptographic keys, and encrypting and signing data in backup files.
- Manageability: By providing innovative and automated policy-based administration, Microsoft SQL Server 2008 lets companies reduce the time and cost of managing their data infrastructure. Improved tools are provided for performance monitoring, troubleshooting, and tuning.

Microsoft SQL Server 2008 R2 is a complete set of enterprise-ready technologies and tools that help organizations derive the most value from information while lowering total cost of ownership (TCO). With Microsoft SQL Server 2008 R2, organizations can:

- Implement peer-to-peer replication quickly with the new visual designer and add nodes without affecting system availability
- Audit all actions across the enterprise and consolidate audit reporting
- Help protect sensitive data with automatic, transparent data encryption
- Use Microsoft Performance Studio to troubleshoot, tune, and monitor Microsoft SQL Server 2008 instances across the enterprise
- Take control of workload resource use with Microsoft Resource Governor
- Store all kinds of business data with native support for relational data, XML, file streams, and spatial data
- Reduce storage requirements and improve performance with data compression, backup compression, sparse columns, and filtered index and backup compression
- Optimize database mirroring performance and eliminate downtime with automatic recovery of suspect pages

Configuration Basics

Correctly sizing solutions for Microsoft SQL Server deployments that feature OLTP applications requires careful consideration of available computing power, memory, and storage subsystems. For example, Microsoft SQL Server 2008 scales extremely well with available computing power and can easily use all available memory.

Appropriate processor and memory configurations can be selected depending on performance and budgetary requirements.

Effective storage system design and layout is likewise essential. Main considerations for the storage subsystem include performance in terms of I/O operations per second (IOPS), capacity, and availability requirements. Typical Microsoft SQL Server OLTP I/O employs an 8-KB block size, with a random read-write ratio of 70:30. Performance is dictated by the number of available spindles and storage controllers. The storage capacity is influenced by the size of the database including auxiliary structures, database transaction log, and temporary database (tempdb) space along with availability requirements such as RAID protection levels.

Table 2 lists the storage capacity and redundancy requirements of various system and database files for small, medium, and large configurations. In Cisco's testing, the Microsoft Windows 2008 R2 operating system and the Microsoft SQL Server 2008 installation files were placed on mirrored internal drives. There is no performance benefit to separating the OS and Microsoft SQL Server on different drives.

Table 2. Capacity and Redundancy Requirements for a Typical Microsoft SQL Server 2008 Deployment

Configuration	Small	Medium	Large	Redundancy Level
OS and SQL installation files (GB)	100	100	100	RAID 1 (mirrored)
Raw database size (GB), excluding:	200	300	500	RAID 10 or 5
Database transaction log (GB)	40	60	100	RAID 10
Tempdb space (GB)	40	60	100	RAID 1, 5, or 10

The database files should be spread across as many spindles as possible to achieve the greatest number of IOPS. Enabling write caching reduces write latency significantly, and it is recommended if the storage controller supports battery-backed write cache (BBWC). RAID 5 offers balanced performance and capacity, and RAID 10 is recommended when performance is of utmost importance.

Transactional workloads do not use make heavy use of tempdb. For greater flexibility to support querying and reporting, tempdb files should be placed on separate drives from the data. Because tempdb is weighted toward write operations, RAID 1 (mirroring) or RAID 10 is recommended. The general recommendation is to create one tempdb file for every two processor cores. Set the recovery model of tempdb to simple. In typical installations, set tempdb files to grow automatically as required. In high-performance environments, preallocating tempdb files to accommodate the maximum expected workload is recommended.

The transaction log uses large block sequential writes, and performance is critical. The log files should be placed on separate drives from the data and tempdb drives. RAID 10 is recommended for the best write performance and recoverability, and RAID 5 can be used in situations where greater capacity is required. RAID 5 is not recommended for the transaction log.

Microsoft SQL Server 2008 Enterprise Edition offers data compression that reduces the size of tables and indexes by storing fixed-length data types in a variable-length storage format. While both row and page compression are supported, row compression gives the greatest benefit in OLTP environments because it reduces both disk storage and IOPS requirements.

Reference Configurations

To evaluate performance and scale, three reference configurations were designed and tested by Cisco engineers. The reference configurations were intended to provide a balance of computing power, memory, and I/O for a range of database sizes, concurrent users, and transactions per hour. By basing deployments on these tested configurations, the risk of failure in terms of implementation and performance can be significantly reduced. The reference configurations can be used as is, or they can be used as starting points for configuring the final system. Small, medium, and large reference configurations were sized to meet a range of needs, as shown in Table 3.

Table 3. Range of Reference Configurations for Microsoft SQL Server 2008 Based on Cisco UCS C-Series Rack-Mount Servers

Reference Configuration	Cisco UCS C-Series Server	Reference Memory Configuration	Storage
Small	Cisco UCS C210 M2 Rack-Mount Server	96 GB	16 internal small form-factor 146-GB 15K-RPM SAS disk drives
Medium	Cisco UCS C250 M2 Extended-Memory Rack-Mount Server	192 GB	EMC CLARiiON AX4 storage system with 36 300-GB 15K-RPM SAS disk drives
Large	Cisco UCS C460 M1 High-Performance Rack-Mount Server	256 GB	EMC CLARiiON CX4-240 storage system with 60 300-GB 15K-RPM Fibre Channel disk drives

Selecting an Appropriate Reference Configuration

Selection of an appropriate reference configuration depends on the database size, number of expected concurrent users, and transaction load. To evaluate the reference configurations, Cisco engineers used a workload that consisted of a set of OLTP transactions typical in a web-based sales system, such as transactions

to check the availability of an item, order an item, make payments, and schedule delivery. Approximate sizing information based on Cisco's testing is shown in Table 4. In each case, the sizing guidance for each reference configuration is conservative. For example, CPU utilization levels were kept under 50 percent, indicating considerable headroom for each reference configuration.

Table 4. Guidelines for Applying Small, Medium, and Large Configurations to Database Size, Concurrent Users, and Transactions per Hour Based on Cisco Testing

Configuration	Small	Medium	Large
Database size (GB)	200	300	500
Concurrent users	1,000	1,500	2,500
Transactions per hour	5,000,000	7,500,000	12,500,000

Small OLTP Reference Configuration

The Small OLTP reference configuration is intended to meet the performance, capacity, and price requirements of typical small and medium-sized businesses (SMBs) and includes:

- Cisco UCS 210 M2 General-Purpose Rack-Mount Server equipped with two Intel Xeon processor X5670 CPUs (3.33 GHz, 12-MB Layer 3 cache, and 130W)
- 96 GB of memory
- 16 internal 146-GB 15K-RPM SAS disk drives

In the context of the reference configuration, the Cisco UCS C210 M2 rack-mount server can be configured with a range of processors, memory, and storage to meet performance, capacity, and budgetary requirements, as shown in Table 5.

As tested, the system featured:

- 48 GB of memory
- 16 internal 15K-RPM 146-GB SAS disk drives

Table 5. The Small OLTP Reference Configuration Can Be Customized with a Choice of Processor, Memory, and Storage Options

Processor Options	2 Intel Xeon series 5600 processors	Intel Xeon X5670, X5650, X5675, L5640, E5649, E5640, E5620, or E5606	
Memory Options	12 DIMM slots	192 GB using 16-GB DIMMs	
		96 GB using 8-GB DIMMs	
		48 GB using 4-GB DIMMs	
Disk Drives	16 front-accessible, hot-swappable, 2.5-inch SAS drives	OS and Microsoft SQL Server and tempdb files	2 x 146-GB 15K-RPM disk drives (RAID 1)
		Microsoft SQL Server transaction log	2 x 146-GB 15K-RPM disk drives (RAID 1)
		Database	12 x 146-GB 15K-RPM disk drives (RAID 5 or RAID 10) or 12 x 300-GB 15K-RPM disk drives (RAID 5 or RAID 10)

Figure 3 illustrates the internal disk drive layout for the Cisco UCS C210 M2 rack-mount server.

- Two disk drives (shown in blue) are configured as RAID 1 (mirroring) for OS, tempdb, and Microsoft SQL Server installation files
- Another two disk drives (shown in teal) are configured as RAID 1 for Microsoft SQL Server transaction log.
- The remaining 12 disk drives (shown in green) are configured as RAID 5 for database files, for a total capacity of 1.5 terabytes (TB).

In the tested configuration, the database and tempdb files were located on a RAID 5 volume using 146 GB for a total capacity of 1.5 TB. Note that higher capacity can be easily achieved by using twelve 10K-RPM 300-GB SAS disk drives instead.

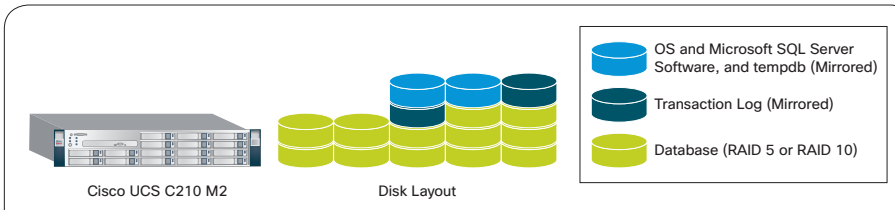

Figure 3. In the Small OLTP Reference Configuration, Internal Disk Drives in the Cisco UCS C210 M2 Server Were Configured for Different Purposes

Medium OLTP Reference Configuration

The Medium OLTP reference configuration is intended to meet the performance, capacity, and price requirements of medium-to-large OLTP environments while offering the ease of use and scalability of the EMC CLARiiON AX4-5 storage system. The Medium OLTP reference configuration consists of:

- Cisco UCS C250 M2 Extended-Memory Rack-Mount Server equipped with two Intel Xeon processor X5680 CPUs (3.33 GHz, 12-MB Layer 3 cache, and 130W)
- 192 GB of memory
- Two internal small form-factor 146-GB 15K-RPM SAS disk drives
- EMC AX4 networked storage with 36 large form-factor 300-GB 15K-RPM disk drives

In the context of the reference architecture, a range of processor, memory, and storage options can be configured, as shown in Table 6.

For testing, the system was configured with:

- Two Intel Xeon processors X5670 (3.33 GHz, 12-MB Layer 3 cache, and 130W)
- 96 GB of memory
- Two dual-port, 4-Gbps Fibre Channel–to–PCIe host bus adapters (QLogic QLE2462)

Figure 4 shows the disk layout for the Medium OLTP reference configuration. Two of the Cisco UCS C250 M2 server's internal drives (shown in blue) are mirrored for OS and Microsoft SQL Server installation files.

The database, tempdb, and transaction log files reside on the EMC AX4-5, which consists of:

- Two-rack-unit (2RU) 12-drive disk processor enclosure (DPE)
- 1RU standby power supply (SPS)
- Second optional SPS
- Three 2RU 12-drive disk array enclosures (DAE).

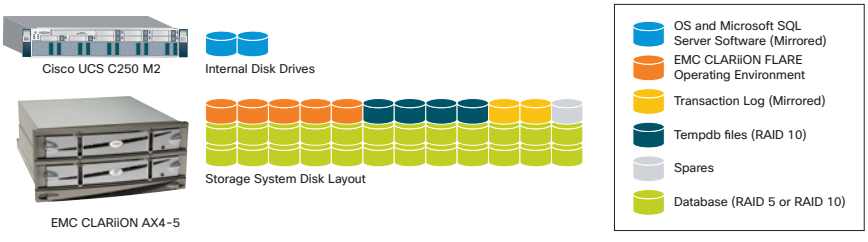

Figure 4. The Medium OLTP Reference Configuration Uses an EMC AX4 CLARiiON Array to Host the Transaction Log, Database, and Tempdb Files

Table 6. The Medium OLTP Reference Configuration Can Be Customized with a Range of Processor Options and Memory Capacities as Performance Needs and Budget Dictate

Processor Options	2 Intel Xeon Series 5600 processors	Intel Xeon X5690, X5680, X5675, X5670, X5650, E5649, E5640, or E5620	
Memory Options	48 DIMM slots	384 GB using 16-GB DIMMs	
		192 GB using 8-GB DIMMs	
		96 GB using 4-GB DIMMs	
Disk drives (Internal)	2 front-accessible, hot-swappable, 2.5-inch SAS drives; 8 supported	OS and Microsoft SQL Server installation files	2 x 146-GB 15K-RPM disk drives (RAID 1)
EMC AX4-5	36 front-accessible, hot-swappable, 3.5-inch SAS drives	EMC CLARiiON FLARE® operating environment	5 x 72-GB 15K-RPM disk drives
		Microsoft SQL Server transaction log	2 x 300-GB 15K-RPM disk drives (RAID 10)
		Tempdb files	4 x 300-GB 15K-RPM disk drives (RAID 10)
		Database	24 x 300-GB 15K-RPM disk drives (two RAID 5 or RAID 10 volumes with 12 disk drives each)
		Spares	1 x 300-GB 15K-RPM disk drive

The DPE contains one storage processor with two 4-Gbps Fibre Channel interfaces, each connected to dual-port, 4-Gbps Fibre Channel–to-PCIe HBAs in the Cisco UCS C250 M2 server. Native Fibre Channel can be connected (as in the tested configuration) to the disk array through Cisco MDS 9000 Family multilayer switches.

As shown in the illustration, the EMC AX4-5 is configured as follows:

- Five 72-GB 15K-RPM disk drives (shown in orange) are reserved for the EMC CLARiiON FLARE® operating environment.
- Two 300-GB 15K-RPM disk drives (shown in yellow) are mirrored and host the Microsoft SQL Server transaction log.

- Four 300-GB 15K-RPM disk drives (shown in teal) are configured as RAID 10 and are used to host tempdb files.
- A single disk drive (shown in grey) is configured as a spare.
- For performance, two RAID 10 configurations of twelve 300-GB 15K-RPM disk drives (shown in green) are configured for database files, yielding a capacity of 3.5 TB. Alternately, if higher capacity is desired, two RAID 5 configurations of twelve 300-GB 15K-RPM disk drives would yield a capacity of 6.5 TB.

Large OLTP Reference Configuration

The Large OLTP reference configuration is intended for large-scale OLTP deployments and combines a Cisco UCS C460 M1 High-Performance Rack-Mount Server with an EMC CLARiiON CX4-240 storage system. Table 7 includes a range of options for the configuration to meet various performance and capacity requirements. The Large OLTP reference configuration consists of:

- Cisco UCS C460 M1 High-Performance Rack-Mount Server equipped with four Intel Xeon processors X7560 (2.26 GHz, 24-MB cache, and 130W)
- 256 GB of memory
- EMC CX4-240 storage system with 60 large form-factor 15K-RPM Fibre Channel–based 300-GB disk drives

Figure 5 shows the disk layout for the Large OLTP reference configuration.

- Two of the Cisco UCS C460 M1 server's 15K-RPM 146-GB internal disk drives (shown in blue) are configured with OS and Microsoft SQL Server installation files.
- Four dual-port 4-Gbps Fibre Channel HBAs (QLogic QLE2462) provide SAN connectivity to the EMC CX4-240 subsystem.

As shown in the figure, the EMC CX4-240 is configured as follows:

- Five 72-GB 15K-RPM disk drives (shown in orange) are reserved for the resident EMC CLARiiON FLARE operating environment.
- Two 300-GB 15K-RPM disk drives (shown in yellow) are mirrored and are used to host the Microsoft SQL Server transaction log.
- Four 300-GB 15K-RPM disk drives (shown in teal) are configured as RAID 10 and are used to host tempdb files.
- A single disk drive (shown in grey) is configured as a spare.
- For performance, four RAID 10 configurations (shown in green) of twelve 300-GB 15K-RPM disk drives are configured for database files, yielding a total capacity of 7.0 TB. Alternately, if higher capacity is desired, four RAID 5 configurations of twelve 300-GB 15K-RPM disk drives can yield 13 TB.

Table 7. The Large OLTP Reference Configuration Can Be Customized with a Range of Processor Options and Memory Capacities as Performance Needs and Budget Dictate

Processor Options	4 Intel Xeon series 7500 processors	Intel Xeon X7560, X7550, E7540, L7555, or E7520	
Memory Options	64 DIMM slots	1024 GB using 16-GB DIMMs	
		512 GB using 8-GB DIMMs	
		256 GB using 4-GB DIMMs	
Disk Drives (Internal)	2 front-accessible, hot-swappable, 2.5-inch SAS drives; 12 supported	OS and Microsoft SQL Server installation files	2 x 146-GB 15K-RPM disk drives (RAID 1)
EMC CX4-240	60 hot-swappable, 3.5-inch Fibre Channel drives	EMC CLARiiON FLARE operating environment	5 x 72-GB 15K-RPM disk drives
		Microsoft SQL Server transaction log	2 x 300-GB 15K-RPM disk drives (RAID 1)
		Tempdb files	4 x 300-GB 15K-RPM disk drives (RAID 10)
		Database files	48 x 300-GB 15K-RPM disk drives (4 RAID 5 or RAID 10 volumes of 12 disk drives each)
		Spares	1 x 300-GB 15K-RPM disk drive

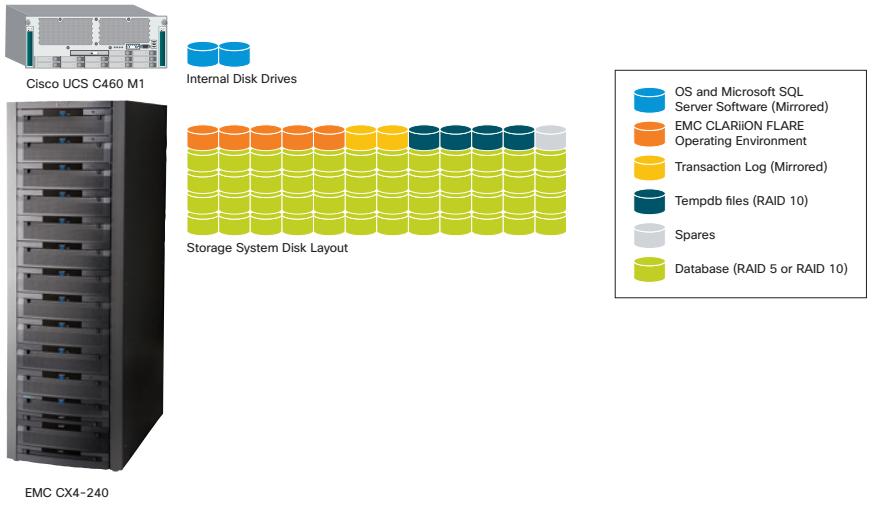

Figure 5. The Large OLTP Reference Configuration Uses an EMC CX4-240 Array to Host the Transaction Log, Database, and Tempdb Files

Although the use cases described in this paper are in the context of the EMC CLARiiON AX4 and CX4 Series models supporting deployments of Microsoft SQL Server with Cisco UCS C-Series servers, the same concepts also apply to the new EMC® VNX™ family of storage systems. These systems include the VNXe™ and the VNX Series storage systems, continuing the EMC tradition of providing one of the highest industry standards in data reliability and availability. The VNXe series delivers one of the easiest, most efficient methods for Microsoft SQL Server deployments with application-optimized wizards, built-in snapshots, replication, and the ability to configure with just a few clicks. The EMC VNX platform has been completely redesigned to meet the demands of a modern data center using the latest processors, drive types, and connectivity options. Additionally, EMC's Unisphere provides ease of management with support for file, block and object, all from a single management framework. Additional information on the VNXe and VNX series platforms is available at: http://www.emc.com/products/family/vnx-family.htm.

Conclusion

The alliance between Cisco and Microsoft joins leading server, software, and networking technologies to deliver optimal value to each company's joint customers. The Microsoft and Cisco alliance is organized to best serve customers and their future requirements through cooperation, a vision that aligns products and services, and a belief that the intersection of networking and software is the core of a new era of innovation.

The OLTP reference configurations based on Cisco UCS C-Series Rack-Mount Servers and Microsoft SQL Server 2008 represent an effective technology combination. By building on these tested reference configurations, organizations can accelerate time to deployment and reduce risk. The reference configurations can be

used as is or as starting points for configuring a customized system that meets the unique needs of the organization.

For More Information

For more information about the Cisco and Microsoft alliance, visit www.cisco.com/go/microsoftalliance or e-mail cisco_microsoft_info@cisco.com.

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