Cisco Unified Computing System: Meet the Challenges of Microsoft SharePoint Server Workloads

What You Will Learn

Occam's razor (according to Wikipedia) … is a principle that generally recommends, when faced with competing hypotheses that are equal in other respects, selecting the one that makes the fewest new assumptions.

Now a mature fourth-generation product, Microsoft SharePoint Server 2010 can be found in most organizations that use other Microsoft products such as Microsoft Active Directory, Windows Server, Exchange, and Office. Microsoft includes Microsoft SharePoint Server 2010 and client access licenses in many of its software licensing bundles, so many organizations can implement Microsoft SharePoint with very low software costs (when compared to competing document management and collaboration tools). When it comes time to design an enterprise-class Microsoft SharePoint Server 2010 environment, however, there are many options that need to be considered in the areas of Microsoft SQL Server design, Microsoft SharePoint front-end server configurations, and configuration of the software itself and the hardware that will run the Microsoft SharePoint Server 2010 farms. Organizations must also plan for the management and governance of the Microsoft SharePoint environment to help ensure that it will continue to offer acceptable levels of performance and reliability into the future. A basic design engagement can take several days of discussions to cover the various options available in Microsoft SharePoint and to allow the designer or architect to try to meet the organization's requirements.

The principal of Occam's razor can be very valuable when applied creatively to Microsoft SharePoint design and governance challenges and can help guide organizations toward the design (consisting of hardware, software, and software configurations) that best meets the organizational needs, resources, and budget constraints of the client. Here is a modified version of the definition for Microsoft SharePoint:

Occam's razor (modified creatively to apply to Microsoft SharePoint designs) … is a principle that generally recommends, when faced with competing **Microsoft SharePoint Server 2010 designs** that are equal in other respects, selecting the one that **has** the fewest **unnecessary complexities.**

With this concept in mind, this document introduces some critical Microsoft SharePoint Server 2010 design concepts and best practices and shows how Cisco Unified Computing System™ (Cisco UCS™) products and features make it well suited for larger and more complex Microsoft SharePoint Server 2010 environments. The design best practices have been accumulated over nearly a decade of designing Microsoft SharePoint environments for companies of all different sizes and show many potential advantages for organizations that choose the Cisco® platform. This document provides technical specifications to readers and assumes a familiarity with the configuration of high-capacity server farms and with networking basics.

Design Challenges with Microsoft SharePoint

A primary concept of any Microsoft SharePoint design is right sizing the Microsoft SharePoint implementation to meet the needs of the organization. For organizations that

already have Microsoft SharePoint installed, typically a previous version of Microsoft SharePoint or the lower-end free version of Microsoft SharePoint Server 2010 called Microsoft SharePoint Foundation 2010, this task tends to be easy because the IT team will have some knowledge of the platform as well as knowledgeable opinions about what worked and what did not in the particular organization. In completely new (greenfield) designs, however, where the organization has little or no Microsoft SharePoint experience, the challenge is to match expectations with best-practice design philosophies gained in the field by the Microsoft SharePoint architect.

Classic errors in design include both overbuilding the Microsoft SharePoint environments and underbuilding them. Overbuilding can result in an overly complex Microsoft SharePoint environment, with a dozen servers or more, often with an overwhelming number of features enabled (such as managed metadata, workflows, forms, business intelligence, and other Microsoft SharePoint Enterprise features) that exceed IT's ability to support them. The feature set can also exceed the user community's skills, especially when sufficient training is not offered, resulting in the impression that Microsoft SharePoint is "too complicated" or "never works right." Underbuilding can yield equally painful results that include slow page loads, time outs during uploads or downloads, system outages, or overly simplistic feature sets that frustrate users.

An increasingly popular concept is cloud computing, in which the cloud consists of multiple servers, storage devices, and networking equipment with a goal being to run applications on demand and scale resources up or down as a specific application demands. Clouds can be private to an organization and hosted in company-owned data centers, or they can be public and hosted by an ever-increasing number of service providers. Microsoft SharePoint Server 2010 lends itself to cloud computing, as will be discussed in this document, because of the large number of servers that are required to meet the performance and availability needs of medium-sized and large organizations and because of the evolutionary nature of most Microsoft SharePoint Server 2010 environments.

With these thoughts in mind, the different main components of a Microsoft SharePoint Server 2010 farm are discussed here, with a focus on Cisco UCS capabilities that should be considered for an enterprise-class Microsoft SharePoint environment.

Building the Foundation of the Microsoft SharePoint Server 2010 Farm

At the core of any network is the hardware and software that allows servers to communicate with each other effectively, including the servers themselves. Because the purpose of this document is to discuss topics specific to Microsoft SharePoint Server 2010, this section focuses on just some specific components of the Cisco UCS platform that are important in this context.

Figure 1 provides a simple Cisco UCS configuration that includes Cisco UCS C-Series Rack-Mount Servers, Cisco UCS virtual interface cards (VICs), and a Cisco UCS 6100 Series Fabric Interconnect. Some of the capabilities of service profiles are shown as well. This figure illustrates the main components of a simple Cisco UCS configuration that could be used for a small to medium-sized Microsoft SharePoint Server 2010 farm.

Figure 1.   Sample Cisco UCS Configuration Showing Main Hardware and Software Components
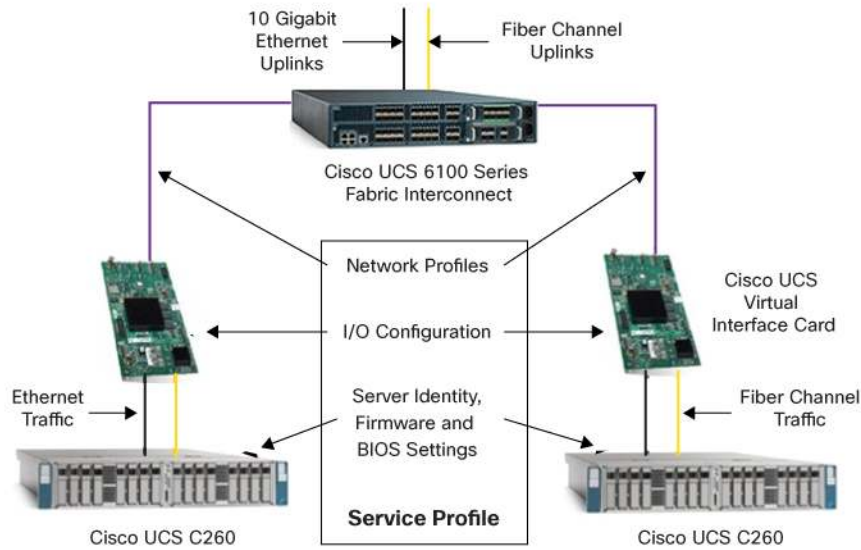
An immediate benefit should be obvious: A single, trusted vendor is providing all the components needed for the Microsoft SharePoint farm. As discussed later in this document, Cisco provides detailed guidelines about specific configurations that are supported for Microsoft SharePoint Server 2010, two of which are covered here at a high level, with links to additional information. Additional capabilities of Cisco UCS include the following:

- **Dynamic provisioning and service profiles**: Cisco UCS Manager supports service profiles, which contain abstracted server states, creating a stateless environment. It implements role-based and policy-based management focused on service profiles and templates. These mechanisms fully provision one or many servers and their network connectivity in minutes, rather than hours or days. This feature can be very valuable in Microsoft SharePoint environments, where new servers may need to be provisioned on short notice, or even whole new farms for specific development activities. For instance, numerous enterprises exist that have more than 15,000 users and have 20 or more development farms to support the development activities occurring on the Microsoft SharePoint platform, so the capability to rapidly provision a new server can be very valuable.

- **Embedded multirole management**: Management is embedded in the fabric interconnects, with all attached systems handled as a single, redundant management domain. Cisco UCS Manager controls all aspects of system configuration and operation, eliminating the need to use multiple, separate element managers for each system component. The result is a reduction in the number of management modules and consoles and better harmonized data center roles for high productivity.

- **Cisco VN-Link virtualization support and virtualization adapter**: Virtual machines get virtual links that allow virtual machines to be managed in the same manner as physical links. Now virtual links can be centrally configured and managed without the complexity of traditional systems, which interpose multiple switching layers in virtualized environments. I/O configurations and network profiles move along with virtual machines, helping increase security and efficiency while reducing complexity. The adapter also helps improve performance and reduces network interface card (NIC) infrastructure.

- **Cisco UCS VICs**: Cisco offers a variety of adapter cards designed for use with Cisco UCS B-Series Blade Servers. All Cisco UCS B-Series network adapters allow reduction of the number of required NICs and host bus adapters (HBAs), are managed through Cisco UCS Manager software, include dual 10 Gigabit connections to the chassis midplane, and can be used in a redundant configuration with two fabric extenders and two fabric interconnects.
- **Cisco Unified Fabric and fabric interconnects**: The Cisco Unified Fabric leads to a dramatic reduction in the number of network adapters, blade server switches, and cabling by passing all network and storage traffic over one cable to the parent fabric interconnects, where it can be processed and managed centrally. This approach improves performance and reduces the number of devices that need to be powered, cooled, secured, and managed. The Cisco UCS 6100 Series offers important features and benefits, including:
  - High-performance unified fabric with line-rate, low-latency, lossless 10 Gigabit Ethernet and Fibre Channel over Ethernet (FCoE)
  - Centralized unified management with Cisco UCS Manager software
  - Virtual machine optimized services with the support for Cisco VN-Link technology

The next critical components of the Microsoft SharePoint Server 2010 environment are the servers, whether virtual or physical, that run Microsoft Windows Server 2008, SQL Server 2008, and SharePoint Server 2010. A critical part of the design process is compliance with organizational standards while meeting the anticipated needs of the organization for the foreseeable life of the technology. For example, some organizations have standards that require all servers to be virtualized, and all designs to meet anticipated end-user requirements for the next three to five years.

Beyond these basic standards, most organizations have standard configurations and builds that are provisioned when new applications are added to the environment. Surprisingly, the process of procuring new servers for a Microsoft SharePoint Server 2010 build or of creating new virtualized servers (which can require more hardware) is often one of the biggest bottlenecks in the implementation process. It is not unusual for the procurement department to need two to four weeks to allocate the hardware, and then one to two weeks for the typically overburdened and understaffed IT departments to configure the servers to meet organizational standards.

Understanding the Cisco UCS product line involves having an idea of the basic product offerings, which start with both rack-mount and blade servers that fit into the Cisco blade server chassis. A high-level overview, along with the basics such as the number of CPUs supported, RAM maximums, number of drives and RAID versions supported, and other statistics, is helpful to get a sense for the number of servers that can be configured and managed on these devices. A helpful piece of historical information is that Cisco, unlike some competitors, was able to build this server line from its foundation and create a product line that is designed for today's computing requirements, with a goal of reducing the overall complexity of configurations by offloading complex processes to modules such as the virtual interface cards and the fabric interconnects. At the same time, Cisco's networking products, software, and accomplishments are legendary, and Cisco's experience in those areas allowed Cisco to create a server architecture that is readily incorporated into the Cisco portfolio of networking products and software.

- **Cisco UCS C-Series Rack-Mount Servers**: The Cisco C-Series servers are rack-mountable servers that come in a variety of configurations. The entry-level and top-of-the-line products have the following capabilities[1]:

  ◦ **Cisco UCS C200 M2 High-Density Rack-Mount Server**: Supports up to two Intel Xeon processor 5600 series; one-rack-unit (1RU) form factor; up to 192 GB of RAM; up to eight internal disk drives; built-in RAID 0 and 1 (SATA only); optional RAID 0, 1, 5, 6, 10, 50, and 60; two integrated Gigabit Ethernet connections; 10 Gigabit Ethernet unified fabric (optional); and two half-length PCIe x8 slots: one full-height and one low-profile slot

  ◦ **Cisco UCS C460 M2 High-Performance Rack-Mount Server**: Supports up to four Intel Xeon processor E7-4800 series; 4RU form factor, up to 1 terabyte (TB) of RAM; up to 12 internal disk drives; no built-in RAID; optional RAID 0, 1, 5, 6, 10, 50, and 60; two Gigabit Ethernet LAN-on-motherboard (LOM) ports; two 10 Gigabit Ethernet ports; and 10 full-height PCIe slots: 4 half-length slots and 6 three-quarter-length slots (two generation -1 slots, and eight generation-2 slots)

- **Cisco UCS 5100 Series Blade Server Chassis:** The Cisco UCS 5108 Blade Server Chassis is 6RU high and can mount in an industry-standard 19-inch rack. It can house up to eight half-width Cisco UCS B-Series Blade Servers and can accommodate both half- and full-width blade form factors. Four hot-swappable power supplies are accessible from the front of the chassis. The rear of the chassis contains eight hot-swappable fans, four power connectors (one per power supply), and two I/O bays for Cisco UCS 2104XP Fabric Extenders. A passive midplane provides up to 20 Gbps of I/O bandwidth per server slot and up to 40 Gbps of I/O bandwidth for two slots.

- **Cisco UCS B-Series Blade Servers**: Cisco B-Series Blade Servers (Figure 2) come in a variety of configurations. The entry-level and top-of-the-line products have the following capabilities[2]:

  ◦ Cisco B200 M2 Blade Server: Supports two processor sockets, Intel Xeon processor 5600 series, 12 DIMMs, up to 192 GB of RAM, two 2.5-inch Small Form Factor (SFF) SAS or 15mm SATA SSDs (up to 1.2 TB), integrated RAID 0 or 1, I/O throughput of up to 20 GBps, and half-width form factor: up to eight per chassis

  ◦ Cisco B440 M2 High Performance Blade Server: Supports four processor sockets; Intel Xeon processor E7-4800 series; 32 DIMMs; up to 512 GB of RAM; four 2.5-inch SFF SAS or SATA drives (up to 2.4 TB); integrated RAID 0, 1, 5, or 6; I/O throughput of up to 40 GBps; and full-width form factor: up to four per chassis

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[1] See http://www.cisco.com/en/US/prod/ps10265/ps10493/c_series_comparison.html for additional models and corresponding information.
[2] See http://www.cisco.com/en/US/products/ps10280/prod_models_comparison.html for additional models and corresponding information.

Figure 2.   Cisco UCS 5100 Blade Server Chassis

Cisco UCS Statelessness

Cisco UCS brings in the concept of statelessness, which allows the personality settings of one server to be applied to another automatically at failover. This feature helps Microsoft SharePoint administrators perform change management activities such as hardware upgrades. It makes use of Cisco UCS service profiles, which capture the configuration settings for servers and the LAN and SAN network access they require and all those low-level device configuration tasks that are needed to get the system up and running, making the failover process highly efficient and quick. Service profiles also link to storage parameters such as the host and storage group for the relevant server.

SQL Architecture

In the default configuration, Microsoft SharePoint Server 2010 stores data uploaded to a Microsoft SharePoint site in a Microsoft SQL Server database, with Microsoft SQL Server 2008 R2 being the recommended version. Because the process of uploading a document to the SQL database is not as efficient as simply storing a file on a file share, optimizing the I/O on the Microsoft SQL Server is very important.

In a Cisco UCS environment, the organization can choose whether to create physical Microsoft SQL Server 2008 servers, or to create a VMware or Microsoft Hyper-V virtual SQL Server 2008 environment and implement a server cluster or high-availability mirror. An example of where this lack of restrictions can be beneficial is in the configuration of multiple Microsoft SharePoint tiers: for instance, development, staging, and production tiers. A larger organization, of 5000 users, might implement a physical Microsoft SQL Server 2008 cluster for the production tier, but then choose to configure a VMware SQL Server cluster for the staging tier and a single VMware SQL Server 2008 back-end for the development tier. Sometimes large organizations (10,000 users or more) realize after a production rollout that a specific configuration does not provide the performance the user community is demanding and have to rebuild part or all of the farm. As Microsoft SharePoint grows in popularity and becomes a mission-critical application, many organizations require high-availability solutions, and these can involve complete failover Microsoft SharePoint farms in co-locations that are geographically separated from the main data center. The capability to copy or clone server images can greatly facilitate this process.

Cisco offers the Cisco Validated Design program, which provides detailed information about fully tested and supported configurations for applications such as Microsoft SharePoint Server 2010. (A link to the document "Microsoft SharePoint 2010 on FlexPod for VMware" is provided in the "For More Information" section of this document.) Specifically, this solution includes the following configuration, with more details provided in Table 1. VMware-Based Configuration on Cisco UCS:

- Four load-balanced web front-end Microsoft SharePoint Server 2010 servers
- Two Microsoft SharePoint Server 2010 application servers with redundant services
- Two Microsoft SQL Server 2008 R2 servers clustered using Microsoft Cluster Server
- Virtual machines deployed using the NetApp VSC vCenter plug-in for VMware vSphere 4.1

Table 1.   Table 1. VMware-Based Configuration on Cisco UCS

Product	Version	Description	Processor	Ram
Microsoft SharePoint Server	SharePoint 2010	Web Front End	Intel Xeon 5680	4 GB
Microsoft SharePoint Server	SharePoint 2010	Web Front End	Intel Xeon 5680	4 GB
Microsoft SharePoint Server	SharePoint 2010	Web Front End	Intel Xeon 5680	4 GB
Microsoft SharePoint Server	SharePoint 2010	Web Front End	Intel Xeon 5680	4 GB
Microsoft SharePoint Server	SharePoint 2010	Application Server	Intel Xeon 5680	4 GB
Microsoft SharePoint Server	SharePoint 2010	Application Server	Intel Xeon 5680	4 GB
Microsoft SQL Server	2008 R2	Database Server (Clustered)	Intel Xeon 5680	16 GB
Microsoft SQL Server	2008 R2	Database Server (Clustered	Intel Xeon 5680	16 GB

VMware vSphere provides many advantages from a configuration and management standpoint, such as the ability to rapidly change CPU and memory configurations during proof-of-concept and user acceptance implementations, and it supports the use of up to eight virtual CPUs per virtual machine. An extremely handy feature of VMware or Microsoft Hyper-V is the capability to take snapshots of server configurations prior to updates or upgrades or new code rollouts. Some organizations are using the virtual snapshots.

The "Microsoft SharePoint 2010 on FlexPod for VMware" document provides a great deal of detail about the configuration and other advantages of the Cisco UCS platform such as traffic isolation, the Cisco UCS M81KR VIC, Cisco Nexus® 1000V Series Switches, and virtual machine networking.

The Cisco white paper "Microsoft SharePoint Server 2010 on Cisco Unified Computing System" (see the "For More Information" section for the URL) provides information about a slightly different configuration for medium-sized farm solution performance and scalability. This configuration uses physical servers on the Cisco UCS platform and uses Microsoft SQL Server 2008 high-availability mirroring. Table 2 provides additional details about this configuration.

Table 2.   Physical Server Configuration on Cisco UCS

Product	Version	Description	Processor	Ram
Microsoft SharePoint Server	SharePoint 2010	Web Front End	Intel Xeon 5680	32 GB
Microsoft SharePoint Server	SharePoint 2010	Web Front End	Intel Xeon 5680	32 GB
Microsoft SharePoint Server	SharePoint 2010	Application Server	Intel Xeon 5680	32 GB
Microsoft SharePoint Server	SharePoint 2010	Application Server	Intel Xeon 5680	32 GB
Microsoft SQL Server	2008 R2	Database Server (HA Mirror)	Intel Xeon 5680	40 GB
Microsoft SQL Server	2008 R2	Database Server (HA Mirror)	Intel Xeon 5680	40 GB

Figure 3 provides a high-level summary of the testing environment that used Cisco UCS hardware and software, as well as Microsoft SharePoint Server 2010 and Microsoft SQL Server 2008 R2. The graph depicts average response-time metrics for the performance test for extreme user loads on the Microsoft SharePoint farm built using Cisco UCS B200 M2 and B250 M2 servers. The designed Microsoft SharePoint Farm supported 50,000

users and achieved a response time of less than one second even for extreme user loads. The spikes in the graph are the result of the web front-end cache flush.

Figure 3.   Microsoft SharePoint Server 2010 Performance Testing Results for Extreme User Loads

Average Response Time
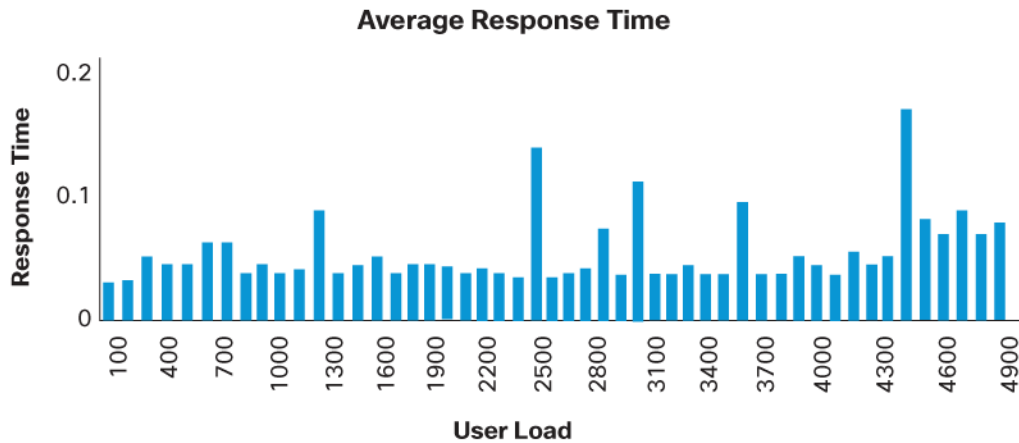
Front-End Servers

After the Microsoft SQL Server design has been completed, the Microsoft SharePoint front-end servers need to be designed. This process involves again determining whether physical or virtual servers are to be used, and then which Microsoft SharePoint components will be installed on which server, and a myriad of other details pertaining to the specific configurations of those service applications using the Microsoft SharePoint Central Administration website.

An enhancement to the functions of Microsoft SharePoint was introduced in the form of service applications in Microsoft SharePoint Server 2010. A service application is defined in Microsoft's TechNet as follows: "A service application provides a resource that can be shared across sites throughout a farm, and can be accessed by users through a hosting web application. Service applications are associated to web applications by service application connections." Table 3 provides a summary of most of the services available in Microsoft SharePoint Server 2010, clarifies which of these services are associated with service applications, and makes recommendations about the type of Microsoft SharePoint Server 2010 server on which to install the service. This information is important to have during a Microsoft SharePoint Server 2010 design, since these service applications need to be assigned to one or more of the Microsoft SharePoint Server 2010 servers, which are typically categorizes into the roles of application servers or web servers.

Table 3.   Main Service Applications in Microsoft SharePoint Server 2010 Standard and Enterprise

| Service	Associated with a Service Application?	Server Recommendation
Application Registry Service	No	Application server
Business Data Connectivity	Yes	Application server
Central Administration	No	Application server
Excel Calculation Services	Yes	Application server
Managed Metadata Web Service	Yes	Application server

Microsoft SharePoint Foundation Incoming E-Mail	No	Web server or application server
Microsoft SharePoint Foundation User Code Service	No	Web server or application server
Microsoft SharePoint Foundation Web Application	No	Web server
Microsoft SharePoint Foundation Workflow Timer Service	No	Web server
PerformancePoint Service	Yes	Application server
Search Query and Site Settings Service	Yes—Search	Application server
Secure Store Service	Yes	Application server
SharePoint Server Search	Yes—Search	Automatically configured to run on the appropriate computers
User Profile Service	Yes	Application server
Visio Graphics Service	Yes	Application server
Web Analytics Web Service	Yes—Web Analytics	Application server

Best-practices recommendations include the following, and as mentioned in the introduction, the theme of simplification of design can be found in many of these:

- Have more than one web server in the farm that hosts the Microsoft SharePoint Foundation web application, which allows end users to access the Microsoft SharePoint sites and data.
- Decide which service applications will go on the web server, bearing in mind that these may affect the overall performance of the web servers, therefore affecting perceptions of performance by the end users.
- Carefully consider which of the application-server-based service applications are truly required for the Microsoft SharePoint solution. Install and enable *only* the service applications that will help enable the organization to meet specific business and technology goals, and consider the skill sets of the IT staff and the user population to both support and use these features.
- Enabling some Microsoft SharePoint Server 2010 Enterprise features, such as Excel services or Performance Point, can put strain on the application and Microsoft SQL Servers and require additional configuration such as the installation of Microsoft SQL Server Analysis Services for Performance Point.
- Installation of companion products such as Microsoft Project Server 2010 or Office Web Applications may justify the addition of other application servers to the farm.

Figure 4 provides an example of a three-tier configuration for what would be considered a medium-sized Microsoft SharePoint Server 2010 farm. In many organizations, these configurations are not static but need to be monitored and tuned over time to help ensure that end-user requirements are being met. A common occurrence is the evolution of the Microsoft SharePoint Server 2010 environment from basic intranet and collaboration functions to an application development platform that supports more advanced capabilities such as business intelligence (BI) applications and complex workflows and business processes or completely customized applications to meet specific business requirements. For this reason, organizations often need to add new servers with very specific functions. These servers may need to be added to the SQL side of the farm or the Microsoft SharePoint side. While the Cisco UCS solution does not provide specific Microsoft SharePoint Server 2010 tools to assist in this process, as discussed earlier in this document, the capabilities of the Cisco UCS platform allow IT to quickly create the base server images, allowing IT to then rapidly install the operating system, SQL, and Microsoft SharePoint software.

Figure 4.   Sample Three-Tier Farm Configuration
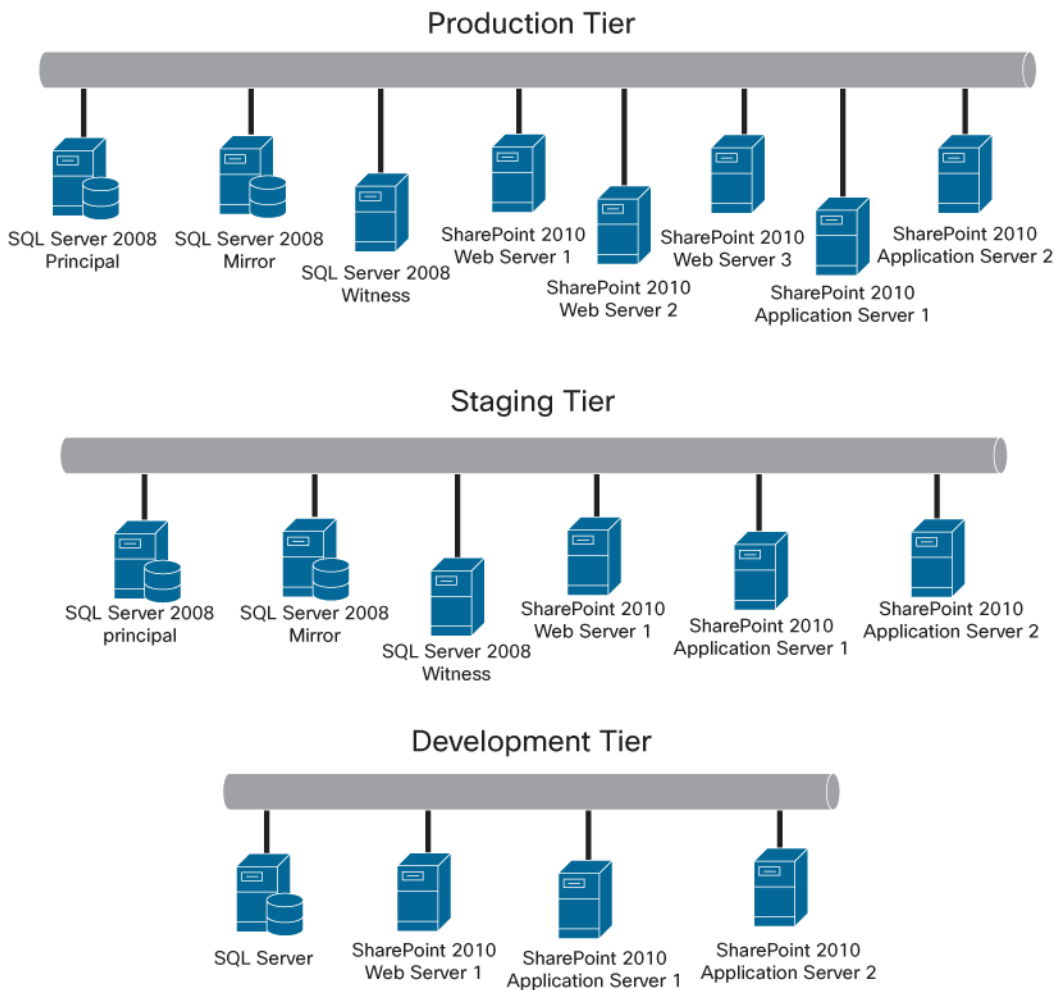
Conclusion

This document introduced the Cisco UCS product line and provided examples of how it can be used to create Microsoft SharePoint Server 2010 farms for organizations of varying sizes and requirements. The concept of simplifying the overall architecture was suggested, and the Cisco UCS product line was covered with a focus on the main components and capabilities that can, both over the short and the long term, simplify the lives of overworked and understaffed IT departments. A great number of components are involved in a multi-tier Microsoft SharePoint Server 2010 environment that will be supporting thousands of end users. Networking components such as hubs and switches and routers are needed; servers or virtual server hosts are needed; and a variety of software products need to be installed, including the operating system, Microsoft SQL Server, Microsoft SharePoint Server 2010, and various management agents; and as anyone familiar with Microsoft SharePoint Server 2010 knows, a great deal of time and energy is required to shape the Microsoft SharePoint configuration into something that will meet the organization's requirements. Nevertheless, the Cisco UCS product line offers a powerful and viable alternative to other solutions that allows IT departments to focus less on making everything work together and more on helping ensure that the Microsoft SharePoint Server 2010 software configuration meets the organization's requirements.

For More Information

Following are a selection of the multitude of reference materials, websites, and white papers available from Cisco, several of which are referred to in the body of this document:

- **Microsoft Enterprise Applications on Cisco UCS:** http://www.cisco.com/go/microsoft

- **Cisco Unified Computing System**: http://www.cisco.com/en/US/netsol/ns944/index.html

  This page provides access to many resources that provide more information about the Cisco UCS platform, including the components that make up this product line, additional resources such as customer case studies, white papers, performance benchmarks, TCO and ROI advisor, and other related Cisco solutions.

- **Microsoft SharePoint Server 2010 on Cisco Unified Computing System:**
  http://www.cisco.com/en/US/solutions/collateral/ns340/ns517/ns224/ns944/cisco_ucs_scalability_performance.pdf

  This document illustrates the performance of a medium-sized Microsoft SharePoint farm, built using Cisco UCS servers implementing three-tier architecture (web, application, and database servers), and shares the test results, which provide guidance and a better understanding of the performance impact of different Microsoft SharePoint workloads, to assist organizations in sizing and designing the best farm architecture to support different workloads.

- **Microsoft SharePoint 2010 on FlexPod for VMware:**
  http://www.cisco.com/en/US/docs/solutions/Enterprise/Data_Center/App_Networking/SharePoint_FlexPod.html#wp401517

  This Microsoft SharePoint Server 2010 Enterprise deployment on FlexPod for VMware design guide demonstrates how enterprises can apply best practices for VMware vSphere, VMware vCenter, Cisco Unified Computing System, Cisco Nexus Family switches, and NetApp FAS.

- **Cisco Unified Computing System (UCS): A Complete Reference Guide to the Cisco Data Center Virtualization Server Architecture**

  By Silvano Gai, Tommi Salli, and Roger Andersson, available from Amazon and other retailers. This book is a very detailed guide to updated material about all server components and new data center technologies and describes how these components and technologies can be used to build a state of the art data center server.