Microsoft® Lync Server™ 2010 Implementation on Dell™ Active System 800v

A Design and Implementation Guide for Lync Server 2010 on Active System 800 with VMware vSphere

Dell Global Solutions Engineering

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Executive Summary

Traditional IT infrastructures have been transformed with the use of virtualization technologies in the datacenter. Some of the benefits of virtualization, including consolidation and availability, have enabled creation of large clusters of managed hardware resources. These architectures improve the ease of management of underlying hardware resources by administrators and enable coexistence of different tiers of enterprise applications on the same hardware.

Dell™ Active Infrastructure is a family of converged infrastructure solutions that combine servers, storage, networking, and infrastructure management into an integrated and optimized system that provides virtualized resource pools. Active Infrastructure helps IT rapidly respond to dynamic business demands, maximize data center efficiency and strengthen IT service quality. Dell Active System 800 is a pre-integrated virtualized infrastructure system that enables IT and business stakeholders to accelerate application and IT service delivery. Designed for reliability, Dell™ Active System 800 eliminates single points of failure and incorporates redundancy into its components.

Critical enterprise applications, including Microsoft® Lync™ Server 2010, were designed to run on dedicated physical hardware with best practices around performance and availability. This ensured the appropriate performance and availability of the application during hardware failure scenarios. However, it also led to the creation of silos of hardware resources dedicated for specific applications. This leads to an increase in management complexity for IT administrators. Therefore, in the suggested reference architecture in this guide, a virtualized set of infrastructure is presented to guarantee availability, flexibility, and consolidation without performance compromise.

This Design and Implementation Guide presents a framework for implementing a Microsoft Lync Server 2010 on Active System 800. This framework builds on the architecture best practices of Active System and uses VMware® virtualization software capabilities to develop rules that allow application virtual machines (VMs) to be deployed and managed without administrators worrying about the exact physical servers on which they might be running. The design also provides dedicated storage resources for SQL databases that are required with Lync Server 2010.

This guide also provides instructions for an instantiation of the application design to support up to 5,000 users using Active System 800. This implementation was then validated for performance and availability by running the Microsoft Lync 2010 Stress and Performance tool[1] to determine steady-state and failure-scenario performance characteristics. In addition, the virtualization resource scheduling features implemented for the application VMs lead to Lync returning to steady-state quickly upon hardware resource failure.

For more information on Active System 800v, please refer to relevant Active System 800v documentation.

NOTE: Web conferencing and video conferencing workloads were not validated in the lab and are beyond the scope of this guide.

[1] The results of this study were taken by using the load generated by the Lync Stress and Performance Tool. It is encouraged to work with Dell Global Infrastructure Consulting Services, especially in deployments that will use these two features heavily or for telephony integration (gateway/PBX interoperability).

Audience and Scope

This guide is intended for IT professionals, consultants, and IT administrators who design and implement Lync Server 2010. This guide helps in understanding the design principles and best practices for virtualizing Lync Server 2010, and provides an overview of how Active System 800 pre-integrated platform architecture benefits the application deployment. It is useful to have a working knowledge of VMware vSphere™ 5.1 and Lync Server 2010 before going through this guide.

Introduction

Recent advancements in server, storage, and networking technology have enabled building efficient infrastructure solutions for the private cloud. Dell's latest hardware portfolio is well equipped to take advantage of the technology advancements and help build solutions with converged network infrastructure. Active System 800v is one of such systems that include the latest Dell PowerEdge™ blade servers, Internet Small Computer Simple Interface (iSCSI) / 10GbE switching and Dell EqualLogic™ iSCSI storage to build private cloud solutions.

Virtualization software from VMware, including vSphere 5.1 with vCenter™ Server, provides fine-grained virtual resource management tools that enable advanced management of application resources to provide reliable performance guarantees and increased availability without tying VMs to individual servers. While the underlying infrastructure is becoming more feature-rich, accurately sizing and validating Lync Server 2010 on such an infrastructure requires a new approach. Some of the considerations include accurately defining resource requirements and maintaining application best practices at the same time, while guaranteeing application performance within the thresholds that are prescribed by Microsoft. As a consequence, a methodology that correctly designs and deploys Lync Server 2010 on new converged infrastructure is essential.

One such methodology is described in this guide. The methodology helps reduce dependencies on the underlying infrastructure from a sizing and deployment perspective, while simplifying the management of Lync Server 2010 ecosystem. It does this by abstracting out the Lync solution in the form of a virtualized pool of resources consisting of memory, CPUs, and virtual network adapters that are provided by Active System 800v. The resource configuration also consists of an appropriate number of VMs pertaining to various server roles that are part of the Lync Server 2010 deployment. The performance of Lync Server is guaranteed as long as the underlying platform is able to meet the configuration requirements of the pool of resources.

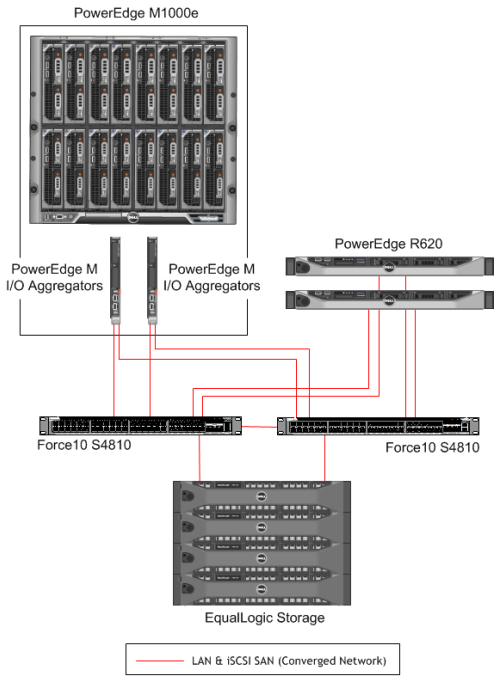
Further, this guide provides the design considerations for Lync Server 2010 on Active System 800, including the best practices that should be considered for deployments of varying sizes. Following this section, the methodology that can be followed for a sample deployment is provided, including details about the networking and storage configuration. Finally, the procedure for gathering results is presented, and a detailed analysis of the performance counters is conducted. Care was taken to not only measure the performance of the Lync Server, but also the Back End SQL component. Some additional features of vSphere 5.1 are also explored, including shares, reservations, limits, and memory locking, as well as the Distributed Resources Scheduler (DRS).

Active System 800v

Active System 800, a member of Dell Active Infrastructure family, is a converged infrastructure solution that has been designed and validated by Dell Engineering. It is available fully racked, cabled, and delivered to the customer site, to speed deployment. Dell Services will deploy and configure the solution tailored for business needs, so that the solution is ready to be integrated into the datacenter. Active System 800 is offered in configurations with either VMware vSphere (Active System 800v) or Microsoft® Windows Server® 2012 with Hyper-V® role enabled (Active System 800m) hypervisors. This guide is based on reference architecture for the VMware vSphere based Active System 800.

Active System 800v offers converged LAN and SAN fabric design to enable a converged infrastructure. The end to end converged network architecture in Active System 800v is based upon Data Center Bridging (DCB) technologies that enable convergence of all LAN and iSCSI SAN traffic into a single fabric. The converged fabric design of Active System 800v reduces complexity and cost while bringing greater flexibility to the infrastructure solution. A high-level diagram of Active System 800v is provided in Figure 1.

Figure 1. Active System 800v



Active System 800v includes Dell PowerEdge™ M1000e blade chassis with Dell PowerEdge™ M I/O Aggregator, Dell PowerEdge™ M620 blades, Dell EqualLogic™ Storage, Dell Force10™ network switches. The solution also includes Dell PowerEdge™ R620 servers as management servers, management related software, VMware vCenter Server and vSphere 5.1, EqualLogic Virtual Storage Manager for VMware, and OpenManage™ Essentials. Table 1 shows the different specifications for servers and storage units that are possible using Active System 800v.

Table 1. Active System 800v Specifications

	8 Blades Configuration	16 Blades Configuration	24 Blades Configuration	32 Blades Configuration
Compute capacity (Total number of cores)	128	256	384	512
Memory Capacity (in TB)	1	2	3	4
Storage Capacity (Raw TB)2	43.2	86.4	129.6	172.8
Number of drives	(2x24) 10K 900GB 2.5" SAS drives	(4x24) 10K 900GB 2.5" SAS drives	(6x24) 10K 900GB 2.5" SAS drives	(8x24) 10K 900GB 2.5" SAS drives

Active System 800v offers increasingly larger amounts of CPU, memory, and storage capacity in moving from the 8 blade to the 32 blade configuration. This can be used as a pool of compute and storage for deploying multiple application workloads. For the purposes of this guide, the eight blades configuration is considered. This configuration includes eight Dell PowerEdge M620 blade servers and two Dell EqualLogic PS6110X storage arrays.

For more information on Active System 800v specification, please refer to relevant documentation.

Lync Server 2010

Lync Server 2010 is the application from Microsoft for real-time communication such as instant messaging and presence, audio-video conferencing, and web conferencing (formerly known as live meeting). Its functionality can be extended by the use of Session Initiation Protocol (SIP) Trunks or PBXs/Voice Gateways to communicate with users on the telephony network (PSTN).

There are a number of different roles for Lync Server, including:

- IM and Presence: The ability to view the status of other Lync users and update status (Busy, Away, Available, etc.) Conferencing with multiple users via IM is also supported.
- Audio Conferencing: Communicate with other Lync users using Session Initiation Protocol (SIP) and Real-time Transport Protocol (RTP). Audio conferencing using Lync is especially cost-effective for enterprises with employees spread across geographical locations because users can communicate using the enterprise data network instead of expensive long-distance telephony.
- Video and Web Conferencing: These workloads are available with Lync Server and can be leveraged for day-to-day tasks in the enterprise. Web Conferencing includes live meeting/Lync conferencing sessions with other users and desktop and application sharing.

[2] Raw capacity. Does not take RAID penalty into account.

NOTE: These two features were not supported by the Stress and Performance Tool[3] that was used in this study. However, in our recommendations later in the paper, an attempt has been made to consider these workloads and a conservative estimate for the server requirements is presented.

- Voice Interoperation with PSTN: Lync Server's Mediation Server role works with a SIP Trunk or telephony device (IP-PBX/gateway) to communicate with telephony users within and outside the enterprise. The Enterprise Voice workload was not tested in this study. It requires the use of Lync Mediation Servers, voice gateways and PBXs. Therefore, if implemented exactly as shown in the Design Framework (Figure 3), the telephony system will work independently of Lync Server. In order to have these systems integrated, the Mediation Server role must be installed and configured to work with the PBX at the enterprise. For Lync integration with telephony, please work with Dell Global Infrastructure Consulting Services.

This guide details the design, implementation and sizing verification for Lync Server 2010 on Active System 800v with eight Dell PowerEdge M620 blades and two Dell EqualLogic PS6110X arrays. One storage array is used to store the operating systems and applications and the second array is used as the SQL datastore to be used by Lync Server 2010.

Dell Services Offerings

Dell Services provides customers a portfolio of professional services including deployment, consulting and support. Deployment services for Active System 800 helps customers deploy and configure the solution ready to be deployed into their datacenter. Dell Consulting for Unified Communications (Lync)[4] service engagement combines Dell's deep expertise with Microsoft's in deploying unified communications systems around the world to deliver a solution that meets business requirements and budget. This cost effective solution addresses both the customer's business and IT needs while ensuring compliance and security.

Dell ProSupport™ [5] for Lync provides customers with a consolidated, single point of contact for their software support needs and ensures solution availability. ProSupport allows customers unlimited access to Dell's 24x7 chat, email and phone support services to help with configuration issues, how-to-assistance, critical patches, updates and disaster recovery.

For detailed services information, please visit dell.com and contact Dell Services representatives.

[3] http://www.microsoft.com/en-us/download/details.aspx?id=25005
[4] http://content.dell.com/us/en/enterprise/by-service-type-it-consulting-communication-collaboration.aspx
[5] http://content.dell.com/us/en/business/d/services/smb-prosupport-for-software-us

General Design Principles

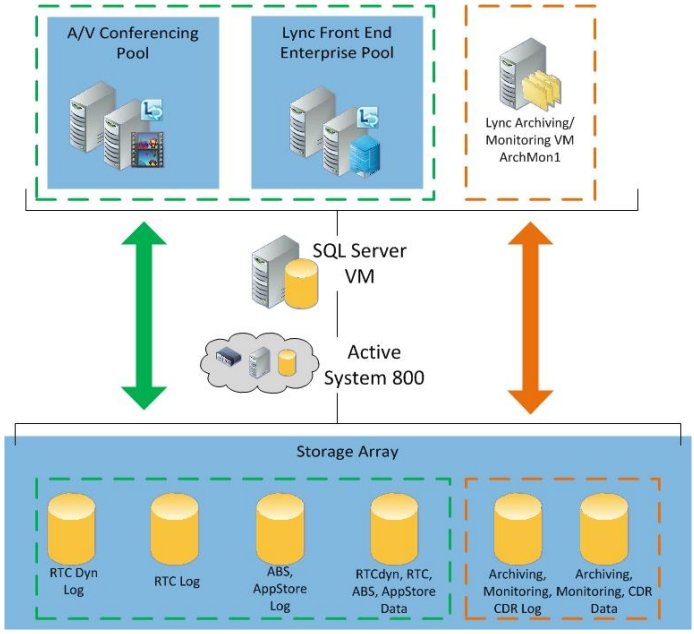
The first component of the lab study was design, which is covered in this section. Following this component, implementation and sizing verification were explored. The primary design goals for the Lync on Active System 800v infrastructure were to effectively leverage the following design principles.

- Ease of Deployment: Active System 800v comes pre-configured with the ESXi 5.1 hypervisor, top-of-rack Force10 S4810 and PowerEdge M I/O Aggregators that support DCB parameters, cabling, and networking configuration. Care was taken to ensure that each of the four networks – application, management, vMotion, and iSCSI have two paths end-to-end from server to switches and iSCSI storage. With all these settings already made, it is possible for IT Administrators to deploy their workloads much more easily.
- Scalability: A sample configuration is presented in the implementation section. This configuration has not only been validated, but also allows room for growth on Active System 800v to run additional workloads or larger Lync deployments. In addition, Active System provides a set of eight, sixteen, twenty-four, or thirty-two PowerEdge M620 blades, thereby making it easier to handle future expansion beyond just a small or medium sized Lync Server deployment. 10GbE networking makes it possible for handling more bandwidth intensive traffic, including Lync video and web conferencing. Each EqualLogic PS6110X storage array provides about 8.63 TB of storage using RAID 10, minimizing capacity concerns. In the largest configuration, it is possible to have eight such EqualLogic PS6110X storage arrays, to be used for different workloads.
- Consolidation: Use vSphere 5.1 to run multiple Lync Servers and other workloads on Active System 800v's set of servers, storage and networking. By doing this, the physical resources are better utilized. With 8-core Intel® Xeon® E5-2660 and 128 GB of memory in the PowerEdge M620, virtualization can be leveraged effectively. Multiple enterprise applications can be consolidated on the pool of available resources.
- Availability: The use of vSphere allows IT datacenters to be more agile. A failed server is no longer a physical box that is not functioning; failed virtual machines can be brought up on another host that has sufficient resources and similar capabilities without human intervention. In addition, using the Distributed Resources Scheduler (DRS) feature available in vSphere 5.1, application availability is enhanced. This feature will be covered later in VMware vSphere 5.1 Features.
- Performance: Each VM has its own share of CPU and memory from the host without compromising the performance. It makes sense to use this capability instead of using a greater number of physical machines to run each Lync Server role on separate hardware. The use of memory locking and reservations to guarantee performance is covered in VMware vSphere 5.1 Features.
- Flexibility: By providing IT Administrators with a set of pre-configured servers, storage and 10GbE networking, combinations of different workloads are possible, making this a flexible offering to suit various datacenter needs. For example, Active System 800v could serve multiple workloads such as Exchange Server 2010, SharePoint 2010, and Lync Server 2010 thereby simplifying day-to-day IT Administration tasks for messaging and collaboration.

Overview of Lync Server 2010 on Active System 800v

The following figure provides an overview of the Lync Server 2010 on Active System 800v that is applicable to deployments ranging up to 5,000 users at a single site. The Enterprise Voice functionality that requires Mediation Servers, is not part of this solution and hence not included in this guide.

Figure 2. Design Overview for Lync Server on Active System 800v



As shown in Figure 2, Lync and SQL VMs can be run on the pool of available resources. This ensures that a VM is not dependent on any particular host and can be migrated on demand or upon host failure. A single SQL instance can be used to host both the Lync Server databases and also the Archiving-Monitoring databases.

NOTE: This is not a single point of failure and the high availability feature provided by vSphere 5.1 is used to failover this VM to a new host. Sizing has been done ensuring that there is high availability.

Lync Server 2010 Best Practices

There are a number of roles in Lync Server. These include the Front End, Audio-Video Conferencing, Back End SQL Server and its databases, and Archiving-Monitoring Server and its databases. The roles not implemented within this paper are the Mediation Server, branch office appliances, and connectivity to the PSTN using a voice gateway or SIP Trunk.

Microsoft recommends that Windows Server 2008 R2 or Windows Server 2008 Standard, Enterprise or Datacenter editions be used based on organizational licensing requirements. For the database, SQL Server® 2008 R2 Enterprise or Standard, 2008 SP1 Enterprise or Standard, or 2005 SP3 Enterprise or Standard are supported. The recommendation from Dell Global Solutions Engineering for Lync 2010 is to use SQL Server 2008 R2 for the database and Windows Server® 2008 R2 for the operating system. Please refer to Microsoft TechNet; the direct links are in the References section at the end of this guide.

For each of the roles that were deployed, precautions should be taken to ensure that multiple instances of the same role are not running on the same host. For example, two Front End roles or two Audio-Video Conferencing roles must not reside on the same PowerEdge M620 blade. This precaution can be taken manually, but the better option would be to use VMware vSphere 5's in-built features as part of Distributed Resources Scheduler (DRS). By doing this, services are still available due to a failure on any one host.

For Lync Server, it is recommended that physical CPUs not be oversubscribed by the VM's virtual CPU. Over-subscribing the CPUs will cause contention for resources. Since Lync works with delay sensitive voice and video traffic, there could be adverse effects due to over-subscription and it is not recommended at this time.

For details of Microsoft Best Practices for Lync Server 2010, please refer to Server Virtualization in Microsoft Lync Server 2010[6]. The next section details some of the components of the AS800 that reduce loss of availability of Lync and any other workloads deployed.

Infrastructure Best Practices

Regardless of the number of Lync seats being considered on Active System 800v, there are a number of best practices that should be followed. Some of the infrastructure best practices include:

- By using high availability provided by vSphere, any given VM can start on any of the available servers in Active System 800v cluster under certain conditions. These conditions include reservations, limits, and DRS rules that will be elaborated later in this guide.
- PowerEdge M620 hosts with identical hardware and configuration are used to avoid performance variations for VMs running on different physical machines.
- Redundant power sources that are provided by the use of two Power Distribution Units (PDUs).

Networking Best Practices

Networking comes pre-configured on Active System 800v. The networking best practices relate directly to Lync Server 2010 and its Back End SQL database server.

- Redundant paths are used from the host Network Interface Cards (NICs) to eliminate single points of failure. Each of two physical adapters has four NPAR[7] partitions connected to four vSwitches. These Active System 800 vSwitches are dedicated to management, vMotion, the application network and iSCSI, with iSCSI offload enabled on that particular NPAR partition. With Lync, these redundant paths are especially important for the application, iSCSI, and vCenter networks. For further details, please refer to relevant Active System 800v documentation.
- The following EqualLogic-specific iSCSI settings have already been made on Active System 800v and are relevant to the Lync Server's Back End SQL Database:

[6] http://www.microsoft.com/en-us/download/details.aspx?id=22746
[7] NIC Partitioning. Further Reading: www.dell.com/downloads/.../Dell-Broadcom-NPAR-White-Paper.pdf

  - Flow Control: priority flow control (PFC) is already enabled at the Force10 S4810 switches and flow control is enabled on the iSCSI NIC.
  - Jumbo Frames: is already set the MTU size to 12000 at the Force10 S4810 switches and 9000 on the iSCSI VMkernels.

- Another best practice is to use MPIO for the storage subsystem. In iSCSI, by using multiple paths between the Dell PowerEdge M620 blade hosts and the virtual machine data stores, single points of failure are eliminated. Therefore, SQL Server databases and the VM data stores can be accessed by two redundant paths. MPIO is made possible by using two fabrics, each with connectivity to two Force10 S4810 top-of-rack switches. On the network adapters, NPAR partitions are made equally to have a total of eight adapters visible to ESXi operating system and in vCenter. These adapters are teamed, one from each physical NIC so that redundant paths exist for all four networks: management, vMotion, application, and iSCSI.
- Active System 800v settings for Data Center Bridging were implemented without any modifications. For more information on DCB Priority-Based flow control (PFC) and Enhanced Transmission Selection (ETS) settings, see relevant Active System documentation.

Storage Best Practices

The storage best practices are outlined below.

- At least one array must be used in a pool meant for the VM Datastore containing the operating systems for each of the VMs required; this can be shared with other application VMs. A second array should be used for the Lync Server databases and logs (Application Datastore). It is recommended that two separate pools, each containing one member, be used instead of a single pool containing both the VM and Application Data stores. This ensures that a dedicated set of spindles serve the VM operating systems and that there is no contention for disk access with Lync databases/logs. Manageability of storage resources is also easier.
- It is strongly recommended to use multiple SCSI controllers in vSphere 5.1 for the SQL database and log volumes. By using multiple storage controllers, it is possible to achieve equal throughput and increase the number of vCPUs that can read and write to the volumes thereby improving the IO performance. vSphere 5.1 allows up to three additional SCSI Storage Controllers in addition to SCSI Controller 0 that is used to access the operating system installation. For more details, please refer to Appendix A.
- For the SQL database, it is recommended to have six separate volumes so that there is sufficient IOPS capacity to handle clients at peak login times. These volumes would be:
  - RTCDyn Log—logs for transient user data such as presence
  - RTC Log—logs persistent data such as contact lists and contacts
  - Archiving, Monitoring, and CDR Log—archiving and monitoring log requirements
  - Archiving, Monitoring, and CDR Data—database volumes for archiving and monitoring
  - ABS and Application Log—address books, and application logs
  - RTCDyn Data, RTC Data, ABS Data, and AppStore Data—all other database files

With Active System 800v, this translates to using six volumes on a dedicated EqualLogic PS6110X storage array. Further details on the SQL requirements are detailed on Microsoft TechNet SQL Server Data and Log File Placement[8] and also later in this guide.

VMware vSphere 5.1 Features

Some features provided by vSphere were used in the Lync Server 2010 implementation, including shares, reservations, and locking. Shares, reservations, and limits can be set for both CPU and memory, but locking is possible for memory only. Shares allow priorities for certain VMs over others, should there be over-subscription of CPU or memory resources. This can happen if the number of vCPUs exceeds the total number of cores presented by the host. The benefit of using shares is that VMs do not have to satisfy any minimum CPU or memory conditions in order to start. However, VMs with higher priorities will have preferential access over VMs with lower priorities and this implies potential performance degradation for these low prioritized VMs.

Instead of using shares, the other option is to prevent any over-subscription of CPU and memory available from the host, thereby avoiding contention and eliminating the need for prioritized access. Reservations and limits allow minimum and maximum CPU and memory to be specified on a per VM basis. By doing so, there is no contention among VMs on a particular host for these two resources. No over-subscription is allowed. The final option for memory is locking, which allows IT Admins to guarantee all the memory specified by best practices. Guidelines for using shares, reservations, limits, and locking are presented in the next section. For Lync, the use of shares versus reservations/locking is a trade-off between performance and availability. With shares, even if resources are not guaranteed, VMs can be failed-over with the potential hazard to the overall performance of workloads running on Active System 800. With reservations/locking, the minimum amount of CPU and memory must be available for a failed Lync VM to migrate to a new host. Should this amount of resource not be available, the VM will not restart on the environment.

Distributed Resources Scheduler (DRS) on vSphere 5.1 ensures that certain conditions are satisfied during the bring-up of VMs on the cluster. The main goal of DRS is to enforce resource allocation policies for workloads. For Lync Server, it is not desirable to have like VMs start on the same host, as this can lead to service interruptions from a failure at that host. For example, in a topology with two Front Ends, it is desirable to have each Front End on a different host. In doing so, should there be a single host failure, the Front End that is still available to service clients temporarily handles all the incoming requests. The second Front End is brought up on another host using high availability provided by vSphere in keeping with the DRS rule, and connections begin to be load-balanced among the two VMs once more after this service interruption. Contrast this failure with what would happen if both the Front Ends were located on the same host and without any DRS rules implemented. If this host were to fail, there would be a noticeable service interruption and all the Lync clients in that pool would abruptly lose access to their messaging platform.

[8] http://technet.microsoft.com/en-us/library/gg398479.aspx

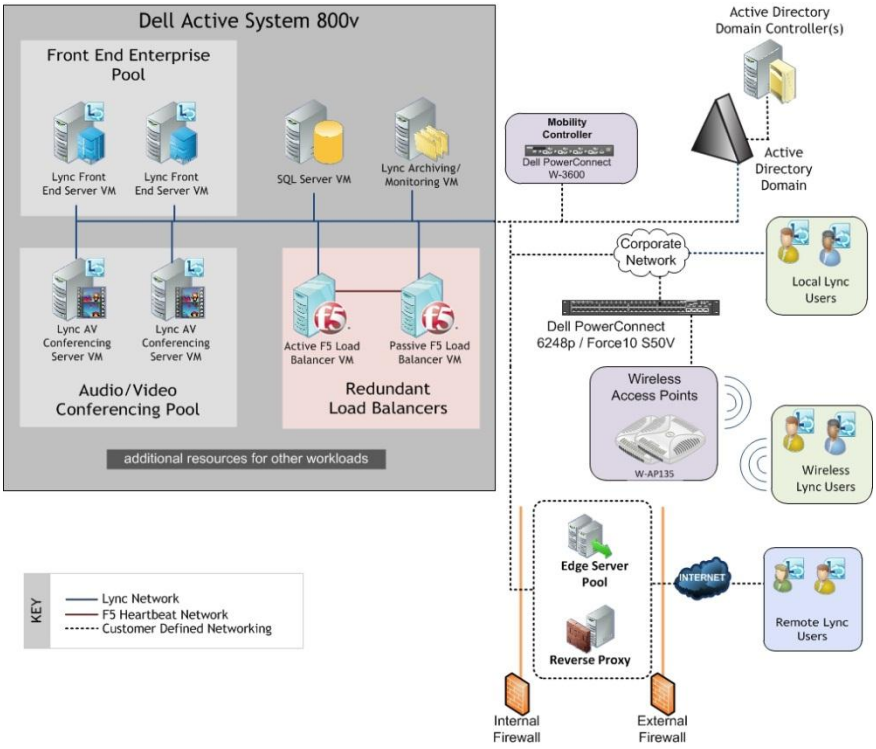
Implementation for 5,000 Lync Users on Active System 800v

The previous section detailed some of the best practices and design principles relevant to Lync on Active System 800v. The following sections cover the configuration that would be required on Active System 800v for Lync Server 2010, starting with Lync Server specific configuration and then followed by networking, storage, and vSphere configuration.

Lync Server 2010 Design Framework

In order to deploy Lync, the first step is to decide on a configuration that will adequately meet the requirements at the enterprise. The following figure provides the design framework that should be sufficient for 5,000 Lync users. This set of Lync and SQL Servers are deployed on a pool of eight Dell PowerEdge M620 blade servers and two Dell EqualLogic PS6110X storage arrays (the eight server configuration on Table 1). Figure 3 shows the Design Framework that was implemented and validated.

Figure 3. Design Framework for Lync on Active System 800v



Based on the planning process, it was determined those two Front-End VMs, two AV Conferencing VMs, two Load Balancer VMs, one SQL VM, and one Archiving-Monitoring VM can handle the load from 5,000 Lync clients[9]. The SQL Server can be placed on a single LAN with Lync Server 2010, but should there be an external SQL Server cluster that can be leveraged, that approach would also work. Table 2 details the requirements for each of the VMs within Active System 800v.

[9] Please consider using Dell Global Infrastructure Consulting Services for larger deployments and for telephony integration

Table 2. Lync Server 2010 on Active System 800v Solution Overview

Converged Infrastructure Major Components	
AS800	Dell M1000e Chassis
	Dell PowerEdge M620
	Dell Force10 Switches
	Dell Equallogic PS6110 Series
	VMware ESXi 5.1
Lync Major Components	
Audio Video Virtual Machines x 2	
Operating System	Windows Server 2008 R2 SP1
Virtual Machine Configuration	4 x vCPU
	11 GB Virtual Memory
Networks	1 x VMXNET 3
	Application Network
Software	Lync Server 2010 SP1-A/V Role
Front End Virtual Machines x 2	
Operating System	Windows Server 2008 R2 SP1
Virtual Machine Configuration	4 x vCPU
	11 GB Virtual Memory
Networks	1 x VMXNET 3
	Application Network
Software	Lync Server 2010 SP1-Front End Enterprise Role
Archiving And Monitoring Virtual Machine x 1	
Operating System	Windows Server 2008 R2 SP1
Virtual Machine Configuration	4 x vCPU
	11 GB Virtual Memory
Networks	1 x VMXNET 3
	Application Network
Software	Lync Server 2010 SP1-Archiving+Monitoring Role
SQL Server Virtual Machine x 1	
Operating System	Windows Server 2008 R2 SP1
Virtual Machine Configuration	4 x vCPU
	28 GB Virtual Memory
Networks	1 x VMXNET 3
	Application Network
Software	Microsoft SQL Server 2008 R2
f5 Big IP Virtual Machines x 2	
Operating System	f5 Big IP Virtual Appliance
Virtual Machine Configuration	2 x vCPU
	4 GB Virtual Memory
Networks	2 x VMXNET 3
	Application Network, Heartbeat Network
Storage Volumes	
RTC Dyn Log	10 GB
RTC Log	20 GB
Archiving, Monitoring, CDR Log	320 GB
Archiving, Monitoring, CDR Data	1750 GB
ABS, AppStore Log	25 GB
RTCdyn, RTC, ABS, AppStore Data	250 GB

As indicated, the memory requirement for nearly all the VMs in the Lync workload is 11 GB. Memory requirement for the SQL Back End is greater because this VM serves as the SQL Server for both the Back End and Archiving/Monitoring functions. 4vCPUs are used for the Lync and SQL VMs.

As mentioned previously, the guidance in the table above was taken after referring to the best practices in Server Virtualization in Microsoft Lync Server 2010[10]. The F5 BigIP virtual appliance was chosen for this guide, and for further details on supported load balancers, please refer to Lync Server Load Balancer Partners[11]. For Active System 800v infrastructure, it does make more sense to use a virtual appliance, but if a hardware load balancer is preferred, that approach can also be taken. In this case, additional ports on the S4810 switches must be configured for this external hardware. Please refer to Active System documentation for additional information on the ports that are vacant on the S4810 top of rack switch. These ports are 18-23 and 37-47 on each of the top of rack switches.

As shown above, two F5 BIG-IP VMs were deployed on the same cluster that contains the Lync Servers as well as any additional workloads that would be deployed on Active System 800v. While the VMs themselves are in a cluster, BIG-IP relies on its own HA mechanism using an active-passive HA-pair. Load balancing for the Lync enterprise pool was enabled through BIG-IP's iApp framework. More details on BigIP Virtual Edition can be found at the Local Traffic Manager website[12].

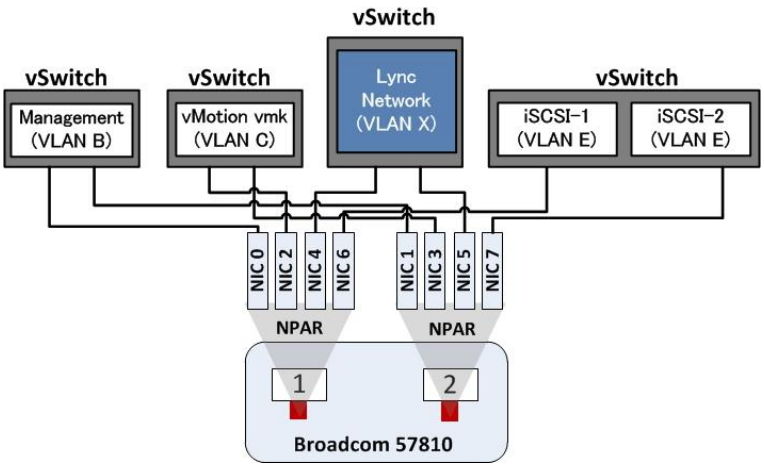
This deployment does not take into account VoIP requirements such as gateways, SIP Trunks and Lync Mediation Servers. The main workloads tested were Instant Messaging+Presence, IM Conferencing, Audio Conferencing, and Application Sharing. Quality of Service of audio conferences was monitored using the Monitoring Server reports. For further guidance on additional functionality including telephony, please contact to Dell Global Infrastructure Consulting Services.

Networking Configuration

The SQL Server was placed on the same VLAN as the Lync Servers. For documentation on how to add a port group and additional VLAN for the SQL Server network, please go relevant Active System 800v documentation. A summary of the networking configuration is provided in Figure 4.

[10] http://www.microsoft.com/en-us/download/details.aspx?id=22746
[11] http://technet.microsoft.com/en-us/lync/gg269419.aspx
[12] https://www.f5.com/products/big-ip/big-ip-local-traffic-manager/overview/

Figure 4. Networking Implementation with NPAR



As shown in Figure 4, Broadcom 57810 is the network adapter that was used by each of the M620 blade servers. It provides two 10GbE network connections that are used for redundancy. A separate VLAN was used for each of the four networks that are created on the Broadcom 57810. Each of these VLANs (B, C, X, and E) was placed on a NIC team such that there is no single point of failure.

NOTE: In the lab the F5 virtual edition load balancer did require a separate network for its heartbeat (indicated in Table 2). Since this configuration is load-balancer specific, it is not elaborated further in this document. For details on configuring additional VLANs on Active System 800, please refer to relevant Active System 800v documentation.

Storage Configuration

As covered in the Design section, six LUNs required are for the SQL database. The recommendation for the LUN sizes is shown in Table 3.

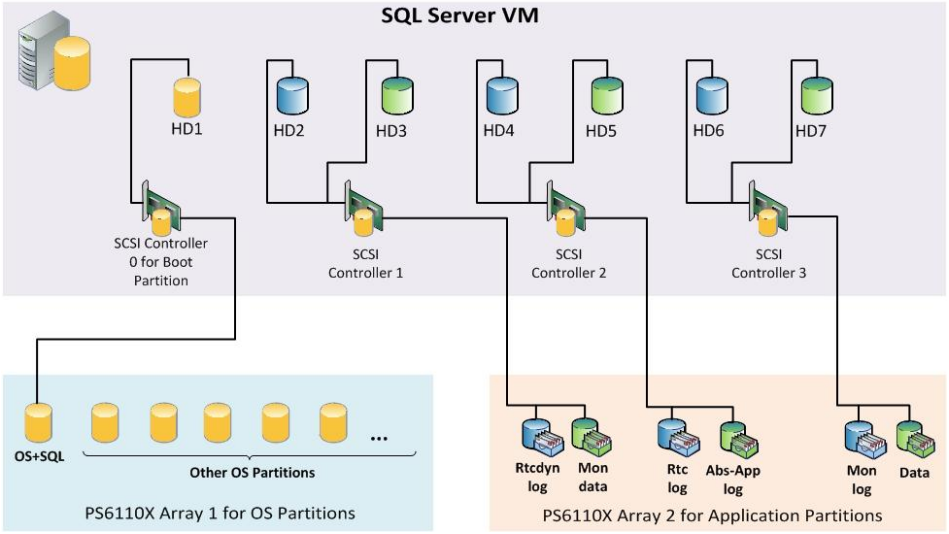
Table 3. LUN Sizes for Lync Databases and Logs

LUN	Contents	LUN Capacity
1	Rtcdyn Log	10 GB
2	Rtc Log	20 GB
3	Archiving Log, Monitoring Log, CDR Log	320 GB
4	Archiving Data, Monitoring Data, CDR Data	1750 GB[13]
5	ABS Log, AppStore Log	25 GB
6	Rtcdyn Data, Rtc Data, ABS Data, AppStore Data	250 GB[13]

[13] Increase capacity for larger deployments

The table above provides a minimum recommendation for these volumes. In an EqualLogic PS6110X array with 8.63TB of capacity (using RAID 10) and 10k SAS spindles, there is room for expansion beyond the suggested sizes. For larger deployments, consider increasing the sizes for LUNs 4 and 6 at the minimum as these contain the SQL databases which can grow in size. Further detail on the connectivity to these volumes from the SQL Server is provided in Figure 5.

Figure 5. SQL Server VM LUNs

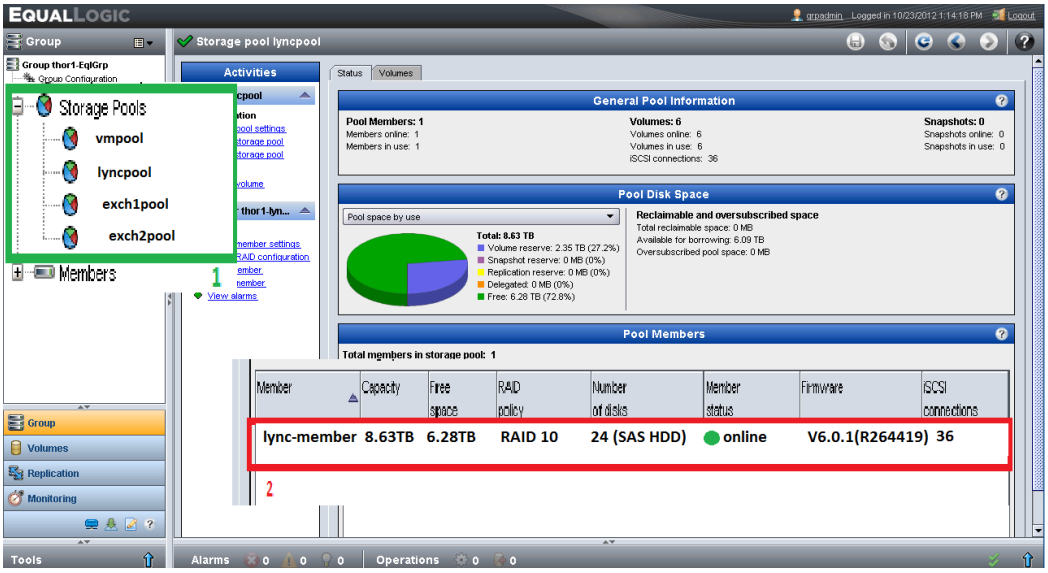


SCSI Controller 0 is used for the OS partition which contains the Windows Server 2008 R2 SP1 and SQL Server 2008 R2 installations. SCSI Controller 0 is used by the Lync Server VMs to access their respective OS partitions as well. In addition to this adapter, three additional SCSI Controllers are used to map to two LUNs each on a separate storage array that is used for the Lync Datastore. By using these vSphere SCSI Controller Devices, volumes in the EqualLogic storage array are mapped to disks that the SQL Server uses for its databases and logs. Transactions on the SQL Database are enabled by connections to the SQL instance from the Lync Servers and Archiving-Monitoring Servers. These servers don't need to have access to the SQL volumes directly.

For storage, the design is implemented following the guidelines in Figure 5.

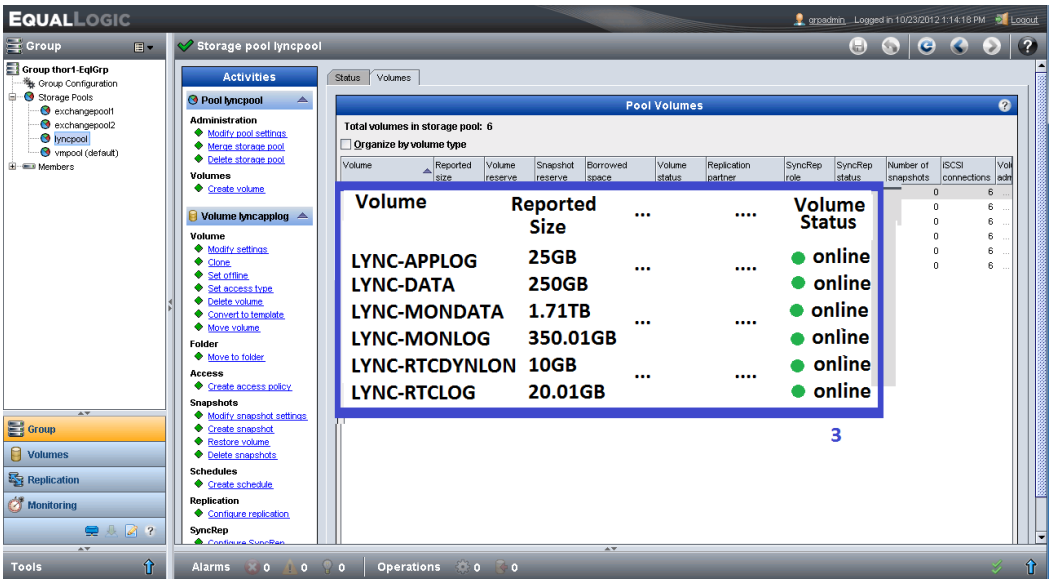
NOTE: Only SCSI Controller 0 is required of the Lync Server VMs. The SQL Server VM requires SCSI Controllers 1 – 3 in addition to Controller 0. Screenshots of the SCSI Controller configuration are shown in Appendix A. The VM Datastore and Lync Datastore volumes are placed on separate EqualLogic PS6110X arrays. For the Lync Datastore, a single dedicated EqualLogic PS6110X member was sufficient. This VM datastore can be shared with other VMs running on Active System.

Figure 6. Screenshot of EqualLogic Member Configuration (Lync)



In Figure 6 above, the **green box** indicates the different pools that are created for the datastores. There are four pools, of which one is the Lync Datastore and one is the VM Datastore. There are two other pools that are used for Exchange 2010 in this case. The **red box** shows the EqualLogic member that is dedicated for Lync Server 2010. This array is dedicated for the Lync Server SQL databases. On this EqualLogic member, six volumes were created as recommended by the guidelines in Table 3. Consider using larger volumes for more than 5000 users, especially for LUNs 4 and 6 - the data volumes. The volumes are shown in Figure 7.

Figure 7. Screenshot of EqualLogic Volumes (Lync Datastore)



The blue box in Figure 7 indicates the six different volumes that were created on the Lync Datastore. This datastore has its own dedicated array and pool, which do not share disks with the VM Datastore and other applications.

Configuration for VMware vSphere 5.1 Features

As was mentioned previously, there is a trade-off between reservations and shares. The easiest way to avoid memory issues is to lock the memory according to best practices provided by Microsoft. A link to these best practices can be found in the References section. Table 4 below outlines the memory lock values that can be used. If reservations and limits must be used, suggested values are presented in Table 4.

Table 4. Reservations, Limits, and Locks

Workload VM	Reservation	Limit	Lock
Lync Front End	6GB	11GB	11GB
Lync AV	6GB	11GB	11GB
SQL Back End	12GB	28GB	28GB
Lync Archiving+Monitoring	4GB	8GB	8GB
F5 BigIP Virtual Appliance	4GB	8GB	8GB

The last column represents the easiest approach for memory allocation while ensuring performance for a Lync deployment. For CPU reservations and limits consider using the equivalent of 2 vCPUs per VM as the minimum and 4 vCPUs for the maximum. The values in MHz are as follows:

- Reservation: 4400 MHz
- Limit: 8800 MHz

These values are set based on 2.2 GHz Intel Xeon E5-2660 processors.

If the requirement is to guarantee availability with a possible compromise in performance of lower priority workloads, shares can be implemented on Active System 800v. Due to the real-time nature of Lync communication, please consider the use of shares seriously prior to use.

In conjunction with reservations/limits or memory locking, DRS rules can be implemented to ensure that Lync Services are up and running in case of a single host failure in Active System 800v. Keeping the DRS design recommendations in mind, the following DRS rules are the easiest way to insure services to Lync clients with minimal impact in cases of failure.

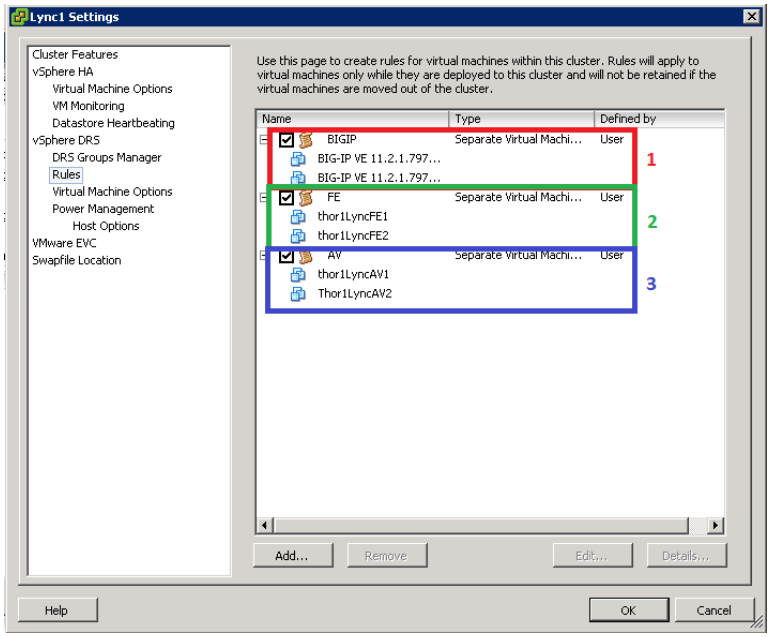
- VM-VM anti-affinity rule 1: FE1, FE2 (Front Ends)
- VM-VM anti affinity rule 2: AV1, AV2 (AV Conferencing)
- VM-VM anti affinity rule 3: BigIP1, BigIP2 (Load Balancers)[14]

[14] Only required if virtual machines are used for load balancing

No DRS rule is required for the Archiving-Monitoring Role. By implementing these rules, it is ensured that the failure of a single host does not interrupt any available Lync services. The VMs on the failed host are brought up on another host, without violating these rules.

The DRS Setting can be set to fully-automated to minimize overhead for IT Administration. The three required rules are summarized in the screenshot shown in Figure 8.

Figure 8. DRS Rules



In the screenshot, the **first rule** is for the load balancer appliances, the **second rule** is for the Front Ends and the **third rule** is for the AV Conferencing Servers. Of course, the first rule is not needed if virtual appliances for load balancing are not used.

Verification Methodology for 5,000 Lync Users on Active System 800v

Since Lync Server 2010 has a number of different components including Front Ends, AV Conferencing Servers, SQL Back End Servers built on top of the ESXi hypervisor there were a number of different components that needed to be validated. The primary components involved in gathering the data required for verification were:

- Performance Verification
- SQL Server Failover Measurements
- DRS Verification

The first component, Lync Server 2010 performance verification involved two smaller tests: Lync Verification and SQL Verification. Two approaches were taken to test and validate the Lync Server 2010 component in Active System 800v environment. In both approaches, 5000 users were logged in and the load was measured on Lync Servers. The two verification approaches were:

1. Two Front-End VMs and two AV Conferencing VMs running under normal operating condition.
2. A single Front-End VM and single AV Conferencing VM running in a failure scenario representing the loss of one Front-End VM and one AV Conferencing VM simultaneously.

   NOTE: This condition will exist for only a short time and does not mean that Lync services will be unavailable. ESXi failover clustering will restart these VMs on another host once it recognizes that these VMs have turned off abruptly. Sizing this Lync solution has been performed so that the load of 5,000 Lync clients could be run on a single Front End and AV Conferencing Server pair, taking into account this worst-case scenario.

For the Back End SQL Server, database performance was measured by monitoring processor, memory and disk IO while increasing the user login rate from 50 users/min to 400 users/min. Assuming that all the users login evenly at 400 users/min, this represents a login period of ~13 minutes, which is a very high login rate. The other extreme of 50 users/min login rate represents a login period of 100 min (one hour and 40 mins) and would be expected to generate smaller load on the SQL Server and its database.

The second part of verification was measuring the SQL failover time. SQL failover was important because the implications of this VM being unexpectedly being turned off need to be studied. The third and final component focused on verification of the DRS anti-affinity rules that were implemented as described in the previous section.

Performance Verification

Testing Tools

The primary tool used for sizing the Lync Server is the Lync Server Stress and Performance Tool[15]. This tool can simulate the following end user features:

- Instant messaging: communication between Lync clients using instant messages.
- Presence: updates to the user status (Available, Busy, Away, etc.)
- Audio, Application Sharing, and IM conferencing: conversations involving multiple parties using audio, instant messaging, and application sharing tools like Microsoft PowerPoint® or Excel®.
- Address book retrieval: one of the servers running the Lync Server in the deployment runs the ABS service. Lync clients download address books from the ABS to complete user look-ups.
- Distribution List Expansion (DLX): Lync uses DLX to retrieve distribution list memberships that would consist of other Lync users.

NOTE: The Stress and Performance Tool does not currently support video and Web Conferencing and the VoIP functionality was not used. Therefore, our final reference architecture is conservative on the number of users that can be supported on Lync VMs, as these workloads may be deployed in customer environments.

The Stress and Performance Tool was set up on multiple VMs to generate the load on the Lync Server(s). For more detailed information on the Lync Stress & Performance Tool and its functionalities see TechNet documentation for the Lync Server 2010 Stress and Performance Tool[16].

[15] http://www.microsoft.com/en-us/download/details.aspx?id=25005
[16] http://technet.microsoft.com/en-us/library/gg679094.aspx

Performance Counters for Front End

Table 5 outlines the performance counters that were measured on the Lync Front Ends.

Table 5. Performance Counters – Front Ends

Lync Front-End Server Performance Counter(s)	Threshold
Connections Active	> 5000
MCU Health State (AS, AV, Data, IM)	0
SIP - Local 503 Responses/sec	~ 0
SIP - Local 504 Responses/sec	~ 0
SIP - Average Holding Time For Incoming Messages (secs)	< 3
DBStore - Queue Latency (msec)	< 100
DBStore - Sproc Latency (msec)	< 100
Memory: Pages/sec	< 2500
Network Utilization (Mbps)	< 4000

To ensure that all the users were logged into the Front Ends, the number of connections was monitored. Hence a threshold of 5000 users was set. "SIP – Local 503 Responses/sec" and "SIP – Local 504 Responses/sec" counters were used to monitor if there were any health issues at the Front Ends. The 503 responses counter indicates that the server is unavailable for client transactions, and 504 responses can be caused by an abrupt client logoff. Both these values should be 0.

The MCU health counters give an indication of the overall system health; these should be 0 at all times, indicating normal operation. The acronyms and their MCUs are listed below:

- Application Sharing (AS): which includes the sharing of desktops and applications like PowerPoint, Word, and Excel.
- Audio-Video Conferencing (AV): which includes audio communication only for the purposes of these tests.
- Data Collaboration (Data): which allows file uploads and downloads and the use of polls during meetings.
- Instant Messaging (IM): which allows text-based real-time communication.

The next counter, "SIP - Average Holding Time" for client transactions should be less than three seconds to allow up to 20 transactions per client. Higher values indicate that that CPU is unable to process client transactions quickly. At values beyond six seconds, connections are throttled, i.e. only one outstanding transaction per client connection is allowed.

The "DBStore – Queue Latency" and "DBStore – Sproc Latency" counters are essential for measuring bottlenecks within the local SQL databases at the FEs; the Queue Latency counter represents the time taken by a request in the Back End's queue. The Sproc Latency counter represents the time taken for these SQL databases to actually process the request.

Active System 800v uses 10GbE networking. There is 5Gbps available using Enhanced Transmission Selection for the application, vMotion, and management traffic and 5Gbps for the iSCSI network by default. For the network utilization 4Gbps (80% of the max available for application, vMotion, and management combined) was set as the threshold. The network utilization was monitored from the Lync

Front End and AV Conferencing VM performance counters. For further details on DCB as used in this infrastructure, please refer to relevant Active System 800v documentation.

Available memory and CPU utilization were taken from the vSphere management console. Additionally, the "memory pages/sec" counter provides the rate of page fetches from disk or other memory locations, and values over a few thousands indicate memory pressure.

Performance Counters for AV Conferencing

Table 6 provides the counters to verify performance of the Audio-Video Conferencing Server.

Table 6. Performance Counters – AV Conferencing Servers

Lync AV Conferencing Server Performance Counter	Threshold
Active Audio Video Conferences	Non-zero
Number of Participants	Non-zero
AVMCU - MCU Health State	0
AVMCU - Number of Add Conference Requests Failed	~ 0
Join Conference Failure	~ 0
Memory: Pages/sec	< 2500
Memory: Page Life Expectancy	> 3600
Network Utilization (Mbps)	< 5000

"Active Audio/Video Conferences" counter indicates the value for the number of conferences being conducted at a given time, and "Number of Participants" shows the number of users participated in these conferences. A non-zero value indicates that conferences with participants were actually taking place. The health of the server was monitored using the "Conference Schedule Failure", "Join Conference Failure" and "MCU Health State" counters to indicate any failure or errors that occurred during the conference's life cycle. Zero or near-zero values indicate healthy AV Conferencing. The available memory was recorded from the vSphere Management Console, in addition to CPU utilization.

Performance Counters for Back-End SQL Server and SQL Database

Back-End SQL Server plays important role in Lync deployment. Table 7 shows the counters observed during the tests.

Table 7. Performance Counters – Back End SQL Server

Performance Counter	Threshold
Memory - Pages/sec[17]	< 2500
Memory - Page Faults/sec[17]	< 2500
Memory - Page Life Expectancy (secs)	> 3600
Logical Disks - reads/sec	NA
Logical Disks - writes/sec	NA
Logical Disks - transfers/sec	NA
Logical Disks - sec/read	< 20ms
Logical Disks - sec/write	< 20ms
Logical Disks - sec/transfer	< 20ms
Logical Disks - Avg disk queue length[18]	< 22
MSSQL - Buffer Manager - cache hit ratio	> 90%

The primary counters of interest in the Back-End SQL deployment are memory, disk, and MSSQL buffer counters. The consolidated results can be found in the next section. The highlighted values for disk IO/sec are found in Appendix B.

The amount of available memory and CPU utilization were taken from the vSphere Management Console. The "Memory - Pages/sec" counter indicates the instances when the SQL Server has to fetch a page from disk after it was not found in its memory. "Memory - Page Faults/sec" counter measures the soft page faults in addition to the hard page faults. These soft page faults occur when pages are found at other locations within main memory and these are not as expensive as retrieving pages from disk. The recommendation is to have both these counters below a few thousands on modern systems such as the Dell PowerEdge M620. Finally, the page life expectancy of less than 3600 seconds (or 1 hour) indicates that the server has run out of memory with progressively lower values indicating more critical memory issues. Therefore, it is desirable to have values greater than 3600 seconds for this counter.

For Logical Disks, the reads/sec, writes/sec and transfers/sec counters have to be checked, taking in to consideration their corresponding latencies. A latency value higher than 10ms is acceptable, but

[17] Refer to: http://blogs.msdn.com/b/jimmymay/archive/2008/10/15/perfmon-objects-counters-thresholds-utilities-for-sql-server.aspx

[18] This number of active disks is 22. Two disks among the 24 disks per array are used for hot spares. (Microsoft guidance)

latencies greater than 20ms indicate an IO bottleneck. The disk queue length is recommended to be below 22 for normal disk performance.

The MSSQL Buffer Manager counter for cache hits indicates the number of page reads or writes issued to physical storage, and because this is expensive, it is recommended to be well above 90%. This will ensure that the server does not have to issue requests for pages from disks and can instead use its memory contents.

Performance Counters from vSphere Performance Charts

vSphere performance charts provide real-time and customized graphs on CPU, memory, network, disk utilization of hosts and VMs. The performance chart data were scheduled for test duration to validate the Lync Server VM's performance. Table 8 provides the counters used for verification.

Table 8. Performance Counters – VMware vCenter

Measurement Units	Description
CPU Usage - %	Amount of actively used virtual CPU, as a percentage of total available CPU. Threshold of 35% under normal operation and 70% in the failure scenario (maximum).
Memory Granted - GB	The total amount of memory that is available to the VM.
Memory Active - GB	Amount of memory that is actively used, as estimated by VMkernel based on recently touched memory pages.
Available Memory - %	The amount of memory that is unused, expressed as a percentage. Threshold is 15% (minimum).

The counters shown in above were measured for Front Ends, AV Conferencing Servers, and Back End Servers. Taken together with the performance counters from the VMs, these counters provide information on the resource usage for the workload with 5000 users.

SQL Server Failover Measurement

This environment has stand-alone SQL Server deployed in a virtual machine. The SQL databases and logs on the EqualLogic storage are accessed by the ESXi hosts using iSCSI. These raw data volumes are then mapped as RDMs to the SQL Server VM. It is critical to understand and validate the database VM failover during host failure to ensure that Lync services are not being affected adversely. As part of this effort, the time taken for the cluster to identify host failure and the time taken for the fail-over to complete were measured.

DRS Verification Procedure

There were two components involved in DRS verification for the cluster. The first part involved ensuring that DRS functioned as desired from the implementation described in the previous section, and the second component was the actual delay in bringing up the VMs within the cluster after the DRS rules were applied. The first component can be subdivided into two parts:

- The observed behavior when there is a host failure, where the host contains at least one AV and one Front End VM and there are sufficient resources on another host that contains the other Front End-AV VM pair. This test makes use of the high-availability feature available in ESXi 5.1.

- The behavior when there is a VM migration that violates one of DRS anti-affinity rules. This could occur if either an AV Conferencing or Front End VM was migrated to another host that already contains another instance of those VMs.

For verification of the failover scenario, the performance counters for client connections at each of the Front-Ends were observed and are documented in the next section.

Results for 5,000 Lync Users on Active System 800v

The following sections outline the performance results from tests on the Front End(s), AV Conferencing Server(s), and Back End SQL Server. First, the performance of the Front-End and AV Conferencing Servers are presented in the normal operation and failure scenario as described in the previous section. Following this, the performance results from the SQL Back End with varying login-rates are described. The effects of SQL being temporarily unavailable are then covered. After this section, the results of DRS verification are explored and finally a few concluding tests on the infrastructure are described. This last part of the verification effort included a short study of the Quality of Service metrics.

Performance under Normal Operation (Front Ends)

This approach contains two Front End and two AV Conferencing VMs running on two different hosts without having the like-roles co-located. Table 9 provides the performance counters, threshold (as per Microsoft Recommendation) and actual data recordings obtained for the Front Ends.

Table 9. Performance Counters for Lync Front End VM

Performance Counter	Threshold	Front End-1		Front End-2	
		Max	Average	Max	Average
Connections Active	**> 2500**	2733	NA	2633	NA
MCU Health State (AS, AV, Data, IM)	**0**	0	**0**	0	**0**
SIP – Local 503 Responses/sec	**~0**	0	**0**	0	**0**
SIP – Local 504 Responses/sec	**~0**	**0**	**0**	**0**	**0**
SIP – Average Holding Time For Incoming Messages	**< 3secs**	0.047	**0.028**	0.057	**0.029**
DBStore – Queue Latency (msec)	**< 100ms**	4.03	**0.815**	2.41	**0.6**
DBStore – Sproc Latency (msec)	**< 100ms**	37.58	**19.88**	62.75	**23.16**
Network Utilization (Mbps)	**< 4000**	4.75	**2.18**	3.70	**2.00**
Processor Utilization[19]	**< 35%**	21%	**14%**	24%	**13%**
Available Memory[19]	**> 15%**	93%	**88%**	91%	**94%**
Memory: Pages/sec	**< 2500**	73	**0.48**	160	**0.812**
Page Life Expectancy	**> 3600**	35526	**21096**	35465	**21004**

[19] From vCenter / vSphere Management Console

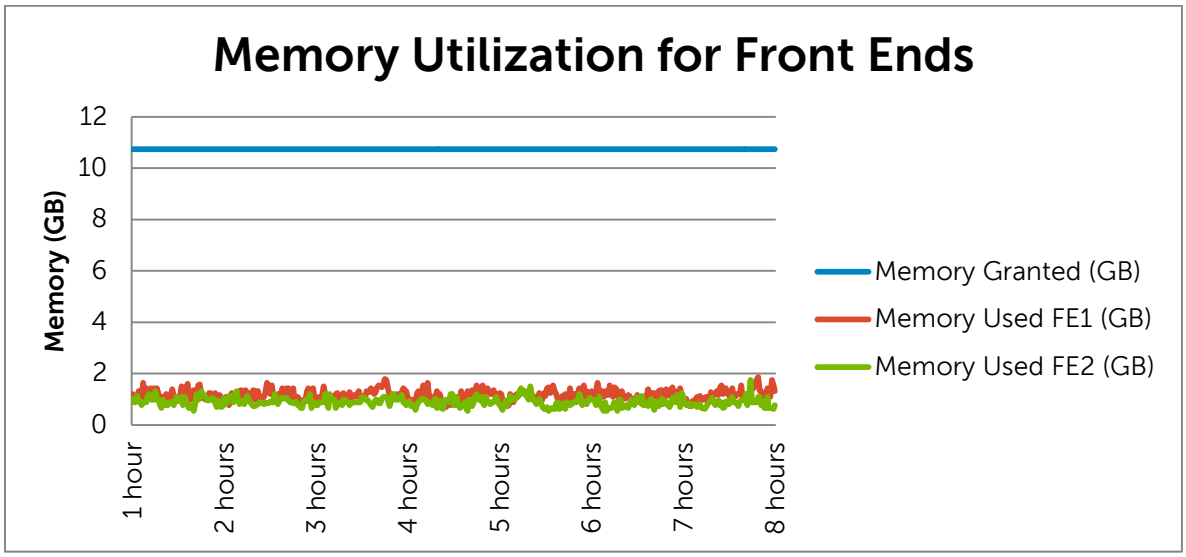
These tests were aimed for sizing 5000 users with high availability of Lync roles. Following the Lync Front End role counters in the above table, we reached maximum of about 5300 total SIP active connections, indicating that the clients were all logged in.

The MCU health counter is zero, indicating normal Lync functionality. Zero values in the 503 and 504 response counters show that there were no SIP connection errors or disconnects. The average holding time is well below the required three seconds, indicating that there was no need for the Front Ends to throttle client requests. The DBStore queue latency and SPROC latency were within the 100ms threshold, indicating no problems with the SQL store on the Front Ends. The network utilization was well below the threshold of 4 Gbps with a maximum value of only 4.75 Mbps.

NOTE: In a real-world scenario with web conferencing, network utilization will be higher.

It was expected that the Front End VM should have at least 15% memory available throughout the duration of the test. This requirement was met. Pages/sec reaches maximum of 72 and average of 1.38, which is below the threshold. Page life expectancy is greater than the threshold of 3600 seconds (1 hour), indicating that there is no memory pressure due to excessive swapping of pages. Data for memory utilization is obtained using ESXi performance data for each Front End guest VM. The memory usage for the entire duration of the test is presented in the chart below.

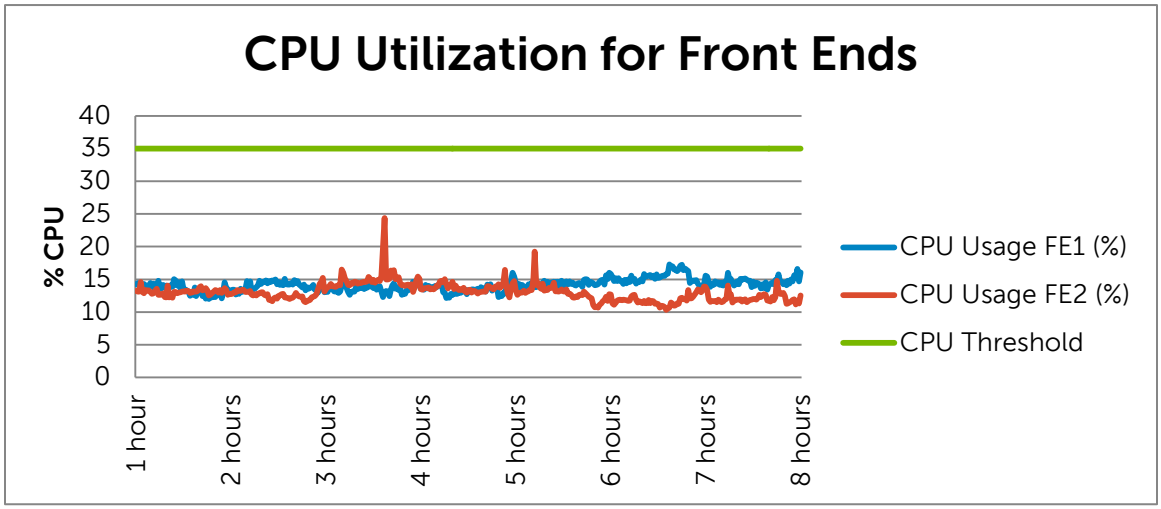
Figure 9. Memory Usage for Front Ends (Normal Operation)



As can be seen above, out of the 11GB of granted memory, less than 2 GB was actively used by the FE1 and FE2 VMs throughout the duration of the test. The recommended 11GB of locked memory is sufficient. Reservation can be considered at 6GB and Limit at 11GB, as shown in Table 4.

VMware ESXi performance data was also used for measuring the guest processor utilization. Assuming that 70% would be the threshold for the failure scenario with 1 Front End, a threshold of 35% was set for normal operation using both Front Ends. Shown in Figure 10 is the CPU utilization with 2 Front Ends.

Figure 10. CPU Usage for Front Ends (Normal Operation)



Utilization of CPU is low, hovering around 15%, when compared to the threshold of 35%. The fact that both Front Ends show similar usage also indicates that clients are almost-evenly load balanced across the two Front Ends.

NOTE: Web Conferencing was not simulated and in a real-world deployment there would be an overhead to these measured numbers. Please work with Dell Global Infrastructure Consulting Services for additional guidelines on your specific deployment.

Performance under Normal Operation (AV Conferencing)

The performance of AV Conferencing VM was measured using several Microsoft Lync Server 2010 performance counters. Additionally, VM CPU and memory usage statistics were recorded from ESXi, in the same way they were recorded for the Front Ends. Table 10 shows the Microsoft Lync performance counters along with their respective threshold values for the AV Conferencing VMs.

Table 10. Performance Counters for Lync AV Conferencing VM

Performance Counter	Threshold	AV1		AV2	
		Max	Average	Max	Average
Active Audio Video Conferences	**Non Zero**	76	**43**	64	**43.23**
Number of Participants	**Non Zero**	185	**90.53**	132	**86.37**
AVMCU - MCU Health State	**0**	0	**0**	0	**0**
AVMCU - Number of Add Conference Requests Failed	**0**	0	**0**	0	**0**
Network Utilization (Mbps)	**< 4000**	2.38	**1.05**	1.62	**1.01**
Processor Utilization	**< 70%**	36	**14**	40	**14**
Available Memory	**> 15%**	99%	**97%**	~100%	**97%**
Memory: Pages/sec	**< 2500**	211	**0.44**	170	**0.43**

There were approximately 43 audio conferences at each AV Conferencing VM as shown in Table 11. Each of these conferences has a number of participants as shown in the second row. The next two counters indicate that AV Conferencing is healthy. The network utilization is well below the threshold of 4Gbps, but in a real-world scenario with video conferencing, this value will be higher.

Figure 11 illustrates the CPU utilization of two AV Conferencing VMs. Results show that on average 13% of CPU is used during the test workloads. For memory, the utilization is less than 1GB of the 11GB that is granted to the AV VMs.

Figure 11. CPU Usage for AV Conferencing (Normal Operation)

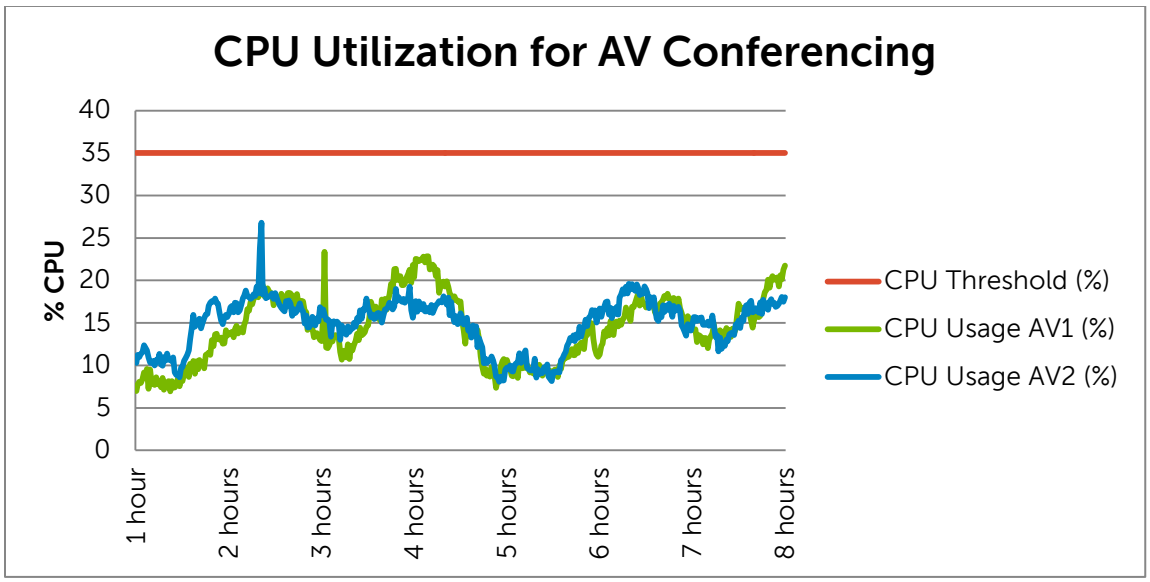
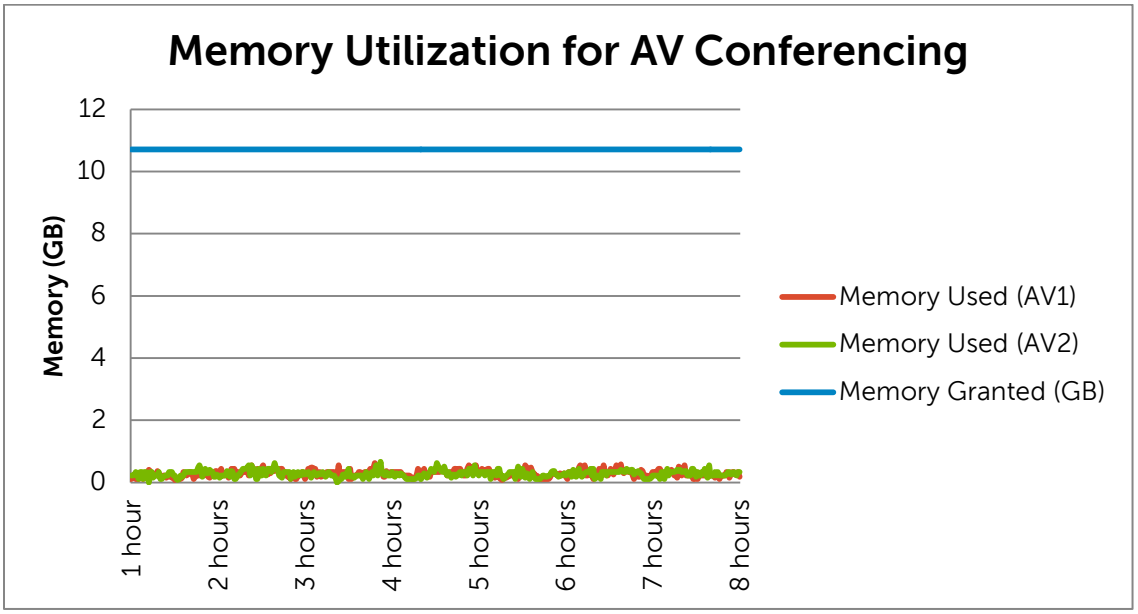


Figure 12. Memory Usage for AV Conferencing (Normal Operation)



As shown in Figure 11 and Figure 12, the CPU usage is generally below 25%. Since only audio conferences are supported by the Lync Stress and Performance Tool, in a real-world deployment with

video conferencing, the CPU utilization will be higher. However, the numbers are well below the 35% threshold for normal operation and it seems safe to assume that even with this extra workload, the CPU threshold will not be exceeded.

For memory, the recommended 11 GB is more than sufficient. Reservation can be considered at 6 GB and Limit at 11 GB, as shown in Table 4. The video conferencing workload's impact should be considered before setting the limit or locking memory.

Failure Scenario (Front End VM)

In this approach, a single Front End was turned-off and the entire load was generated on the other server that is online. In the real-world, in the case of such a host failure, Lync Server VM would failover to another actively running host in a cluster. However, there will be a short time during which a single Front End will have to serve all the clients.

Table 11 shows the performance counters tested and results obtained. Network utilization counters are not shown because the same network load was generated in this scenario as the previous case.

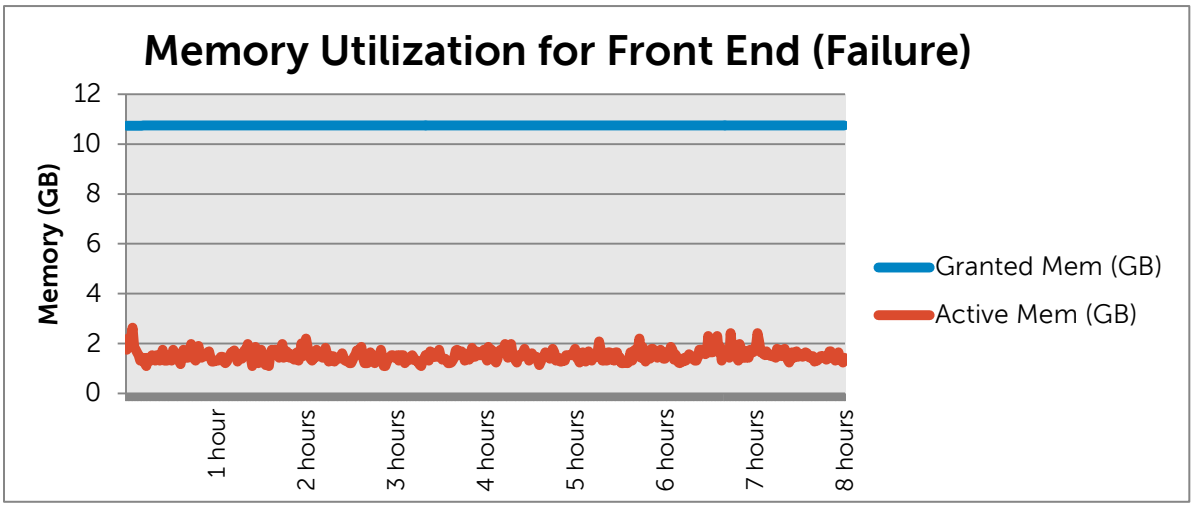
Table 11. Performance Counters for Lync Front End VM (Failure Scenario)

Performance Counter	Threshold	Max	Average
Connections Active	**> 5000**	5363	**NA**
MCU Health State (AS, AV, Data, IM)	**0**	0	**0**
SIP - Local 503 Responses/sec	**~0**	0	**0**
SIP - Local 504 Responses/sec	**~0**	0	**0**
SIP - Average Holding Time For Incoming Messages (secs)	**< 3s**	0.11	**0.046**
DBStore - Queue Latency (msec)	**< 100ms**	8.53	**1.89**
DBStore - Sproc Latency (msec)	**< 100ms**	52	**24**
Processor Utilization	**< 70%**	39%	**23%**
Available Memory	**> 15%**	90%	**84%**
Memory: Pages/sec	**< 2500**	18.66	**0.48**
Page Life Expectancy	**> 3600**	30678	**16277**

Again, the number of clients logged in was above 5000 and the MCU Health State was at the required zero value. The number of connections is comparable to those seen in the normal operation scenario of 5366. There are no significant concerns with the 503 or 504 error responses. The average holding time for messages is well below the threshold of three seconds. The Queue latency and Sproc latency counters are under the 100ms threshold. From Table 12, there seem to be no issues with the pages/sec or the page life expectancy counters. The processor utilization reaches a maximum value of 39%.

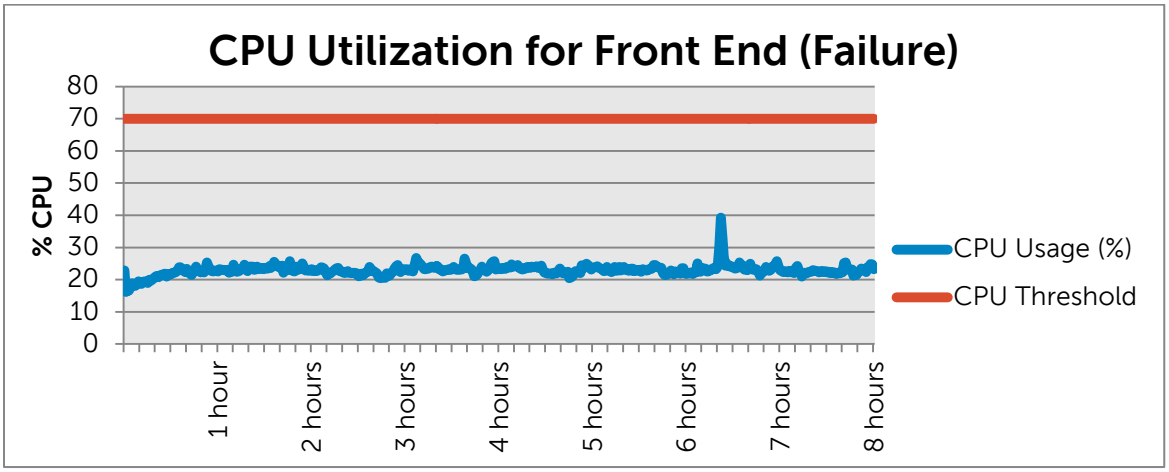
Memory available for Front End VM should be at least 15%. The data captured and depicted in Figure 13 shows that more than 80% of memory is available.

Figure 13. Memory Utilization for Front End (Failure Scenario)



Less than 2GB of memory is used to serve 5,000 clients on a single Front End. Processor utilization is well below the threshold of 70% through the entire duration of the test as shown in Figure 14.

Figure 14. CPU Utilization for Front End (Failure Scenario)



Note that the values shown above are higher than those in Figure 10 with both Front Ends operating. The CPU utilization for a single Front End with 5,000 Lync clients appears to be well below the 70% acceptable limit. Therefore, even in the failure scenario, the workload has been sized appropriately.

Failure Scenario (AV Conferencing VM)

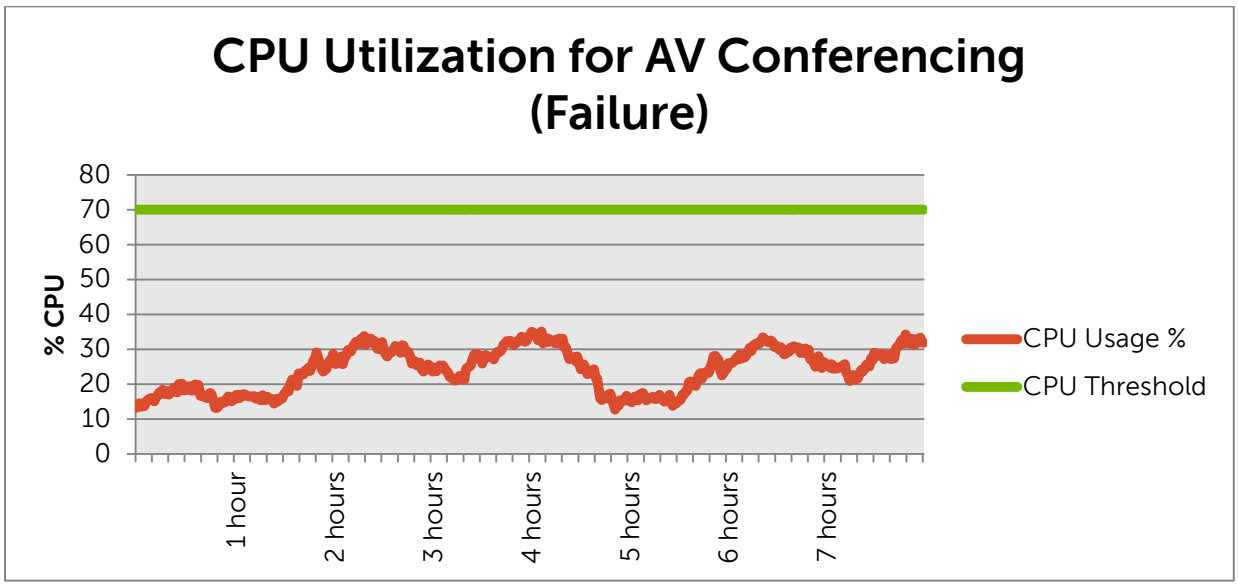
For the AV Conferencing Server, the failure scenario tests were conducted by shutting down one AV Conferencing VM and running the load of 5000 Lync clients on a single VM. The same counters outlined earlier were used in this case, and the results are presented below. As was the case with the Front End failure scenario, the network utilization counters are not shown here since this data was already provided in the normal operation sections for both the Front End and AV Conferencing cases.

Table 12. Performance Counters for Lync AV Conferencing VM (Failure Scenario)

Performance Counter	Threshold	Max	Average
Active Audio Video Conferences	**Non Zero**	123	**89**
Number of Participants	**Non Zero**	275	**182**
AVMCU - MCU Health State	**0**	0	**0**
AVMCU - Number of Add Conference Requests Failed	**~0**	0	**0**
Processor Utilization	**< 70%**	38	**24**
Available Memory	**> 15%**	~100%	**99%**
Memory: Pages/sec	**< 2500**	3.6	**0.013**

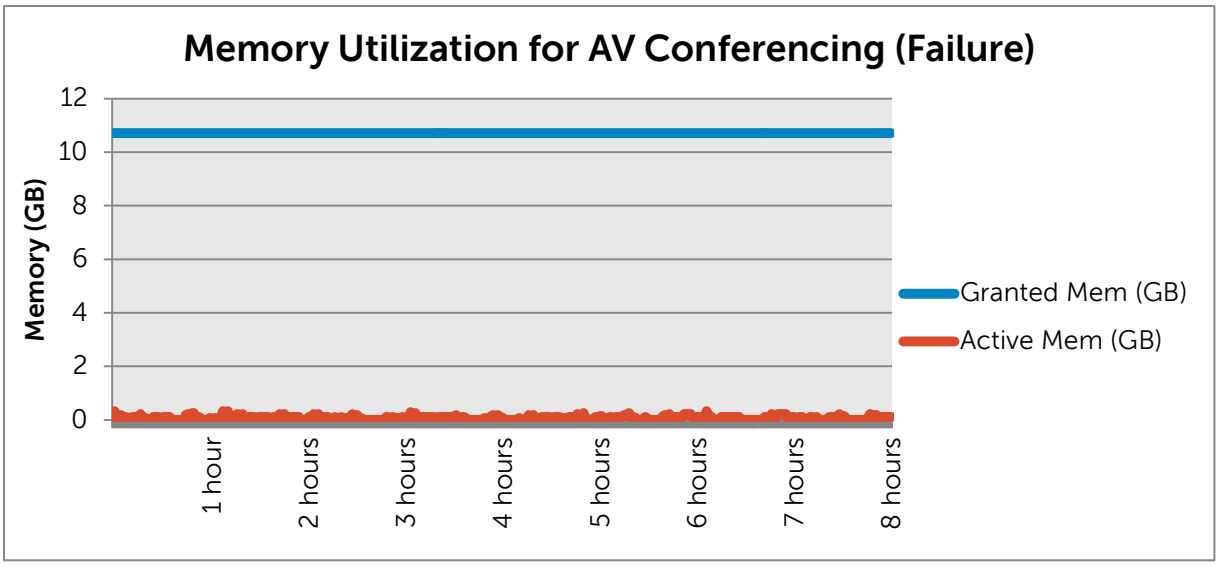
As shown in Table 12, there are 89 conferences on average during the duration of the test. This compares closely with the 86 conferences that were observed in the normal operation scenario. The AV MCU health state is at the required zero value and there were no failures during the test. Since this is failure scenario, the processor utilization threshold was increased to 70% (double of 35% set for the previous case with 2 Front Ends). At 24% utilization, it appears that this condition is also satisfied. A chart of the CPU utilization through the entire run is presented in Figure 15.

Figure 15. CPU Utilization for AV Conferencing Server (Failure Scenario)



The CPU utilization in the failure scenario for AV is well below the threshold of 70%. Compare the utilization here with the values obtained in Figure 11 for normal operation with two AV Servers that shows values ranging between 5% and 25%. For memory, as indicated in Table 13, utilization is very low, leaving available memory at 95% on average for the entire duration of the test. The memory usage for the 8 hour duration is shown in Figure 16.

Figure 16. Memory Utilization for AV Conferencing Server (Failure Scenario)

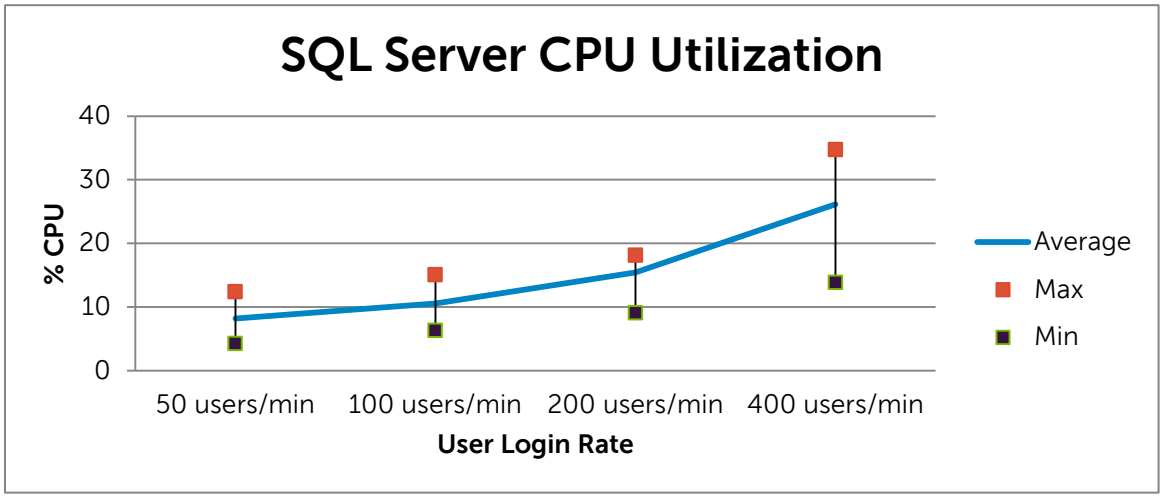


Memory utilization is very low for the AV Conferencing Server, even in the failure scenario. The same point is indicated from the pages/sec counter on Table 12. Utilization can be expected to be greater with the video conferencing workload that would be present in a real-world deployment. Both CPU and memory values indicate that even in the failure scenario, the utilization was within thresholds for the audio workload that was tested.

Back-End SQL Performance with Custom User Login Rates

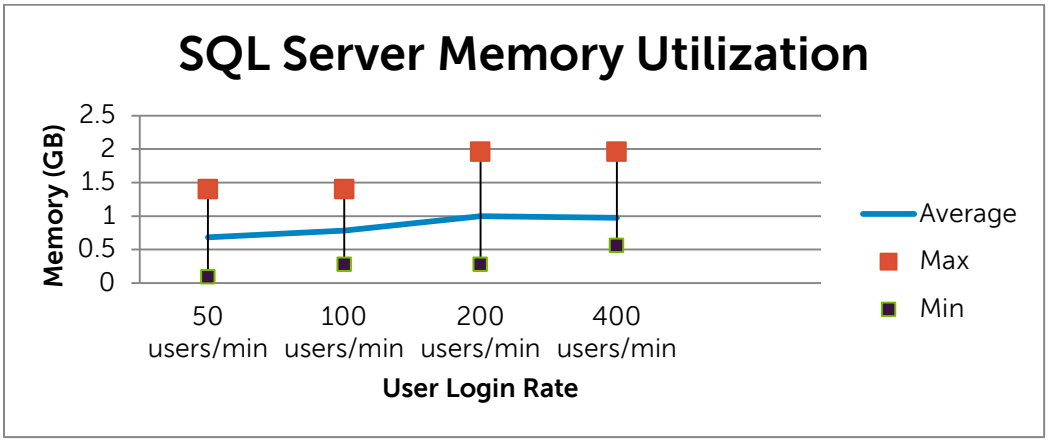
The results for the SQL database were measured during user login periods because during this time, the SQL Server is most stressed. The primary metrics that were measured were CPU, memory, and disk IO. The tests were conducted using performance counters from the SQL Server and vCenter over login rates of 50 users/minute, 100 users/minute, 200 users/minute, and 400 users/minute.

Figure 17. SQL Server CPU Utilization



CPU utilization progressively increases from the lowest login rate of 50 users/min to the highest login rate of 400 users/min. The maximum value for each of these login rates is also progressively higher. Because the CPU is within 35% (on average) at even the peak login rates, no CPU-related performance issue is expected. For memory, vCenter performance charts were used to capture the VM's usage. As was the case with the AV Conferencing VM, the memory utilization for the Back End SQL Server is also extremely low, as shown in Figure 18.

Figure 18. SQL Server Memory Utilization



Even at the peak login rate of 400 users/minute, the maximum memory needed was about 2GB. The following section deals with the other memory counters that were measured, from the SQL Server VM. Table 4 shows the reservation and limit for CPU and memory, and memory lock that can be set.

Table 13 shows the data gathered for the three primary memory counters: pages/sec, page faults/sec, and page life expectancy. The values for pages/sec and page faults/sec are within the set threshold that was set and page life expectancy is greater than the 1 hour limit. This is expected, as there appears to be only a fraction of the memory used for even the highest login rate of 400 users/min.

Table 13. Memory Counters for SQL Server

Memory Counters	Threshold	50 Users/Min	100 Users/Min	200 Users/Min	400 Users/Min	
Page Faults / Sec	**< 2500**	384.8	351.61	1645.34	2485.4	Maximum
		91.3	**96.41**	**74.03**	**351.1**	**Average**
Pages / Sec	**< 2500**	3.87	9.4	136.9	390	Maximum
		0.349	**0.8**	**0.3**	**12.0**	**Average**
Page Life expectancy	**> 3600**	10346	7909	10870	6231	Maximum
		6596	**4250**	**5469**	**3411**	**Average**

One value of concern was identified – the page life expectancy for 400 users is slightly below the one hour threshold. However, this test was run multiple times and it was decided that since this value is quite close to the requirement, the difference is tolerable. The value of 3411 is only about 3 minutes below the one hour threshold that was set.

Disk Utilization

Detailed disk utilization results are provided in Appendix B. From this data, the data below was extracted, showing the maximum and average IOPS required during the login periods.

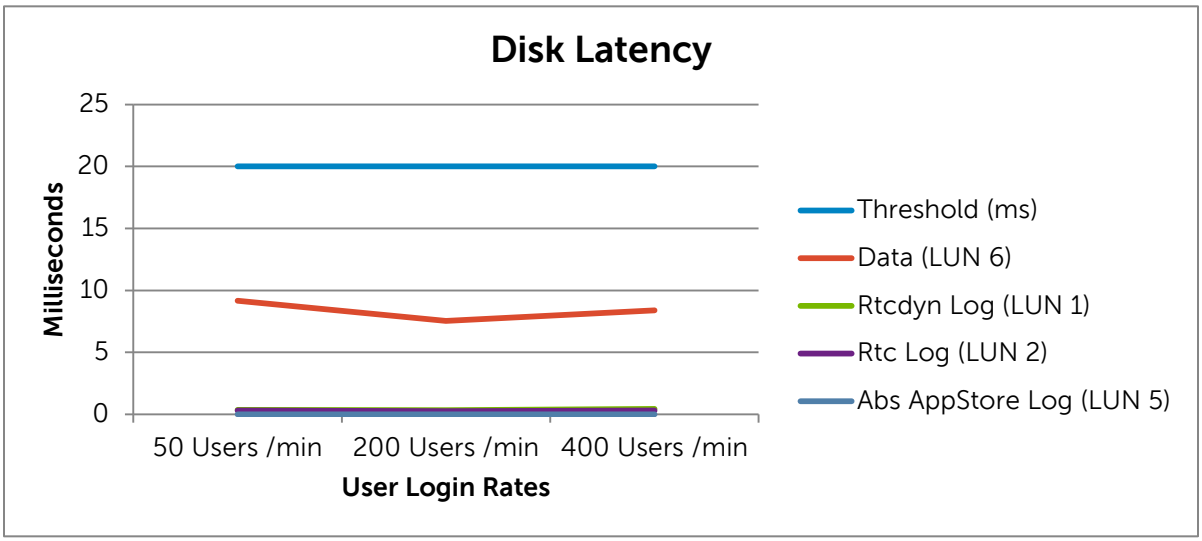
Table 14. Total IOPS Requirements

	50 users/min	100 users/min	200 users/min	400 users/min
Max IOPS	518	801	1191	1110
Average IOPS	**77**	**108**	**100**	**168**

As can be seen from Table 14, the average IOPS increases from around 77 at 50 users/min to 168 at 400 users/min. For a PS6110X array using 22 active 10k SAS disks in RAID 10, the achievable IOPS is around 2,640, assuming 120 IOPS per spindle. This single array provides enough disk performance to handle very high login rates, such as 400 users/min without disk bottlenecks. Both capacity and IOPS requirements for a 5,000 user deployment are well within the capabilities of the Dell EqualLogic PS6110X. There is sufficient room for future expansion to increase the volume size while guaranteeing performance.

For the Back End SQL store, disk latency was noted, in addition to IOPS. The latency during the login period is shown for the three scenarios and these were well below the threshold of 20ms.

Figure 19. Disk latencies for SQL



As shown in Figure 19, the latencies on the data volume (LUN 6) are higher than the others, but within the acceptable limit of 20ms. The final few counters that were analyzed were the disk queue length on each of the logical volumes and the cache hit ratio counter from MS-SQL. These values are shown below.

Table 15. Disk Queue Lengths

Disk Queue	Threshold	50 users/min	200 users/min	400 users/min
Rtcdyn Log (LUN 1)	**< 22**	0.04	0.06	0.26
Rtc Log (LUN 2)	**< 22**	0.00	0.02	0.02
Mon Data (LUN 3)	**< 22**	1.97	8.06	0.25
Mon Log (LUN 4)	**< 22**	0.03	0.07	0.00
App Log (LUN 5)	**< 22**	0.00	0.03	0.00
Data (LUN 6)	**< 22**	1.77	5.01	5.21
MSSQL – Cache Hit Ratio	**> 90%**	100	100	99.99

From Table 15, the disk queues and cache hits for the SQL database were well within thresholds. The low disk queues indicate that there is no IO bottleneck and the high cache-hit ratios indicate that memory was sufficient for the SQL database and that pages could be fetched from the cache at most times. The network utilization by the SQL Server during these high login periods was only a small fraction of the 10Gbps of available bandwidth.

SQL Server Failover Results

The SQL Server is stand-alone in this design. When this server fails, the VM is brought up on another host within the cluster. The following table shows a break-down of the SQL service interruption during the automated failover provided by vSphere 5.1.

Table 16. SQL Failover Measurements

Measurements for SQL Server Failover	Time Taken
VMware Cluster to identify Host failure	~ 30 seconds
SQL Server failover	~ 5 minutes

From Table 16, the SQL VM reboot is complete in about five minutes and Lync users can logout and log back in to gain full functionality at this time. During this time it is possible to communicate with other users using IM and conferencing. Past conferences can also continue and only the presence status of users and the contact lists are affected.

The major functionalities affected for this short time are only the user-specific contact lists and presence status updates. It is possible to manually search users on the address book and communicate

with them. The results indicate that a stand-alone SQL Server with the clustering capabilities provided by vSphere 5.1 is sufficient for this deployment.

DRS Results

As was mentioned in the previous section, there were two components to DRS verification, the first testing the functionality and the second involving time measurements of failure of a host in the cluster.

For the first scenario, when there is a host failure, DRS anti-affinity rules were applied successfully and Front End and AV Conferencing VMs were always brought up on hosts other than those that already contained these VMs. For VM migration, ESXi 5.1 allows vMotion of like VMs as directed by the Administrator. However, within seconds, the violation of the anti-affinity rule causes one of these similar VMs to be live migrated over to another host.

Next, the observed behavior in connections when there is a failover of a Front End Server was noted. In this case, Font End 2 (FE2) was failed-over from one host to another with the DRS rules in place. The observed behavior was a ramp-up in the number of connections for Front End 1 (FE1) to about 3000 from 2500 during the time that services are being brought up on the lost VM. At approximately six minutes, FE2 is once again online and connections begin to be transferred back to it from FE1.

NOTE: Though there was a failover of a Front End, there is no service downtime. Lync services are available on the other Front End Server that is running through this entire failover period.

Quality of Service

To conclude the sizing verification of Lync Server 2010 on Active System 800v, the quality of service of audio conferencing was studied. The following table outlines the QoS measurements that were obtained from the Lync 2010 Monitoring Server's Quality of Experience Reports.

Table 17. QoS Statistics

Scenario	Poor Call %	Round Trip Time (ms)	Degradation (MOS)	Packet Loss	Jitter (ms)
Threshold	< 1%	< 200	< 0.5	< 0.1%	< 20
Normal Operation	0%	1.00	0.01	0.00	1.00
Failure Scenario	0%	1.00	0.01	0.00	1.00

From Table 17, round trip time is the time taken for a packet to travel from one Lync client to another, including the receiver's acknowledgement to the transmitter. High round trip times indicate choppy voice quality. The MOS metric measures call degradation using voice algorithms. Packet loss happens in all TCP/IP networks but at high levels can reduce audio quality. Finally, jitter occurs when audio packets arrive at irregular intervals, also causing loss of audio quality.

Both in the normal operation with two Front Ends and two AV Conferencing Servers and in the failure scenario with one Front End and one AV Conferencing Server, the QoS values are within thresholds. There does not seem to be any QoS issue for the audio calls in this reference configuration of 5000 users. With extensive video conferencing (beyond the scope of this guide), these values could trend closer to the thresholds.

Conclusion

This guide focused on the deployment of Lync Server 2010 on Active System 800v platform with eight Dell PowerEdge M620 blades and two EqualLogic PS6110X storage arrays. This Dell offering also features Dell Force10 switches that are pre-configured. The server, storage and networking hardware serve as a pool of resources which can be leveraged for Lync Server 2010. It can be seen from the results that the infrastructure provided is more than sufficient for 5,000 users and can be used for larger deployments as well. For this deployment, there were no issues with CPU, memory, and storage IO. However, video conferencing, web conferencing, and Enterprise Voice were not within the scope of this study. Therefore, deployments with heavy video/web conferencing use and those that require telephony integration will be best executed after working with Dell Global Infrastructure Consulting Services.

The benefits of Active System 800v platform are not restricted to Lync Server 2010 alone. It is possible and encouraged to leverage this set of resources for multiple workloads. This consolidation of different enterprise applications provides availability without compromising performance. Using features of vSphere 5.1 such as reservations, shares, memory locking, and Distributed Resources Scheduler (DRS) further enhances the capabilities of this system. The underlying 10GbE networking platform also leverages features of Data Center Bridging, including Enhanced Transmission Selection (ETS) and Priority Flow Control (PFC), thereby providing a better networking stack than the previous generation of separate 1GbE networks for LAN and SAN traffic.

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Active System 800v Documentation

- Please browse to: http://www.dell.com/us/enterprise/p/dell-active-system-800/pd

Lync Server 2010 Documentation

- Sizing Guidance: http://www.microsoft.com/en-us/download/details.aspx?id=22746
- TechNet: http://technet.microsoft.com/en-us/library/gg398616(OCS.14).aspx
- OS Requirements : http://technet.microsoft.com/en-us/library/gg412883.aspx
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- Memory Performance Counters: http://www.vmware.com/support/developer/vc-sdk/visdk400pubs/ReferenceGuide/memory_counters.html
- CPU Performance Counters: http://www.vmware.com/resources/techresources/1067
- Distributed Resources Scheduler: http://www.vmware.com/products/datacenter-virtualization/vsphere/drs-dpm.html

Dell Server, Storage, and Networking

- Dell PowerEdge M620: http://www.dell.com/us/enterprise/p/poweredge-m620/pd?~ck=anav
- Dell PowerEdge M IO Aggregator: http://www.dell.com/us/enterprise/p/poweredge-m-io-aggregator/pd
- Dell Force10 S4810: http://www.dell.com/us/enterprise/p/force10-s-series/pd?c=us&s=biz
- Dell EqualLogic PS6110X: http://www.dell.com/us/enterprise/p/equallogic-ps6110x/pd

Appendix A: SCSI Controller Configuration

Figure 20. SCSI Controller Configuration for Lync Servers

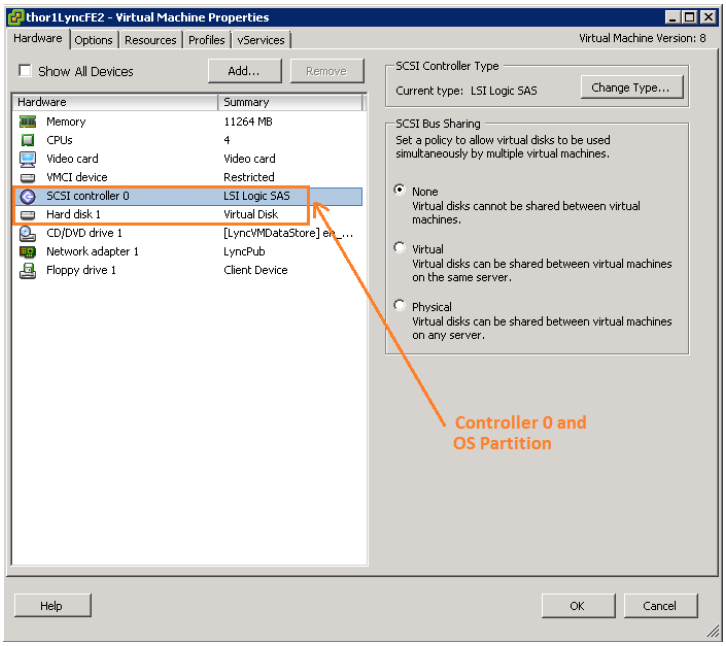
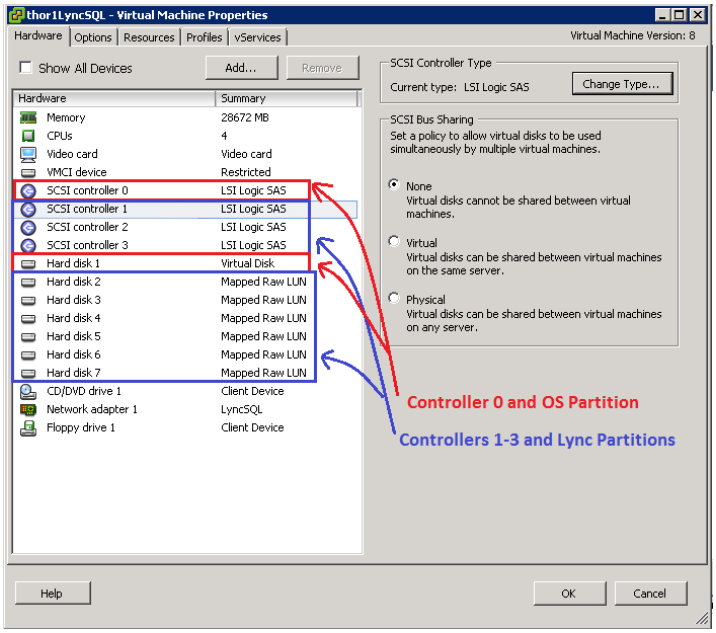


Figure 21. SCSI Controller Configuration for SQL Back End



Appendix B: SQL Database IOPS

Table 18. Disk Transfers/sec for SQL Database

Database Name	50 Users/Min	100 Users/Min	200 Users/Min	400 Users/Min	
DATA	73.29	69.83	193.70	200.15	Max
	5.34	6.34	4.11	14.77	Average
RTCDyn Log	40.02	172.06	88.77	88.17	Max
	22.43	31.05	26.88	37.90	Average
RTC Log	6.85	17.91	24.52	40.52	Max
	4.22	6.16	5.02	17.03	Average
App Log	0.00	0.00	63.52	0.00	Max
	0.00	0.00	0.14	0.00	Average
MON DATA	116.79	110.82	208.10	212.03	Max
	2.44	2.05	2.15	5.88	Average
MON Log	13.20	20.07	15.33	14.55	Max
	6.79	8.71	11.56	9.74	Average

Table 19. Disk Reads/Sec for SQL Database

Database Name	50 Users/Min	100 Users/Min	200 Users/Min	400 Users/Min	
DATA	9.93	6.07	0.10	0.00	Max
	0.44	0.39	0.01	0.63	Average
RTCDyn Log	0.10	0.02	0.02	0.00	Max
	0.0008	0.00	0.00	0.00	Average
RTC Log	0.00	0.00	0.00	0.00	Max
	0.00	0.00	0.00	0.00	Average
App Log	0.00	0.00	0.00	0.00	Max
	0.00	0.00	0.00	0.00	Average
MON DATA	8.33	13.95	3.50	0.00	Max
	0.56	0.43	0.01	1.40	Average
MON Log	0.02	0.02	0.02	0.00	Max
	0.0003	0.00	0.00	0.00	Average

Table 20. Disk Writes/Sec for SQL Database

Database Name	50 Users/Min	100 Users/Min	200 Users/Min	400 Users/Min	
DATA	73.14	69.83	193.70	200.06	Max
	4.35	5.94	4.10	14.14	Average
RTCDyn Log	40.02	172.06	88.77	88.17	Max
	21.95	31.05	26.88	37.90	Average
RTC Log	6.85	17.91	24.52	40.52	Max
	4.16	6.16	5.02	17.03	Average
App Log	0.00	0.00	63.52	0.00	Max
	0.00	0.00	0.14	0.00	Average
MON DATA	116.61	110.79	208.10	211.96	Max
	0.96	1.62	2.14	4.39	Average
MON Log	13.20	20.05	15.33	14.55	Max
	6.57	8.71	11.56	9.81	Average