Overview of Microsoft Private Cloud with Dell EqualLogic Storage Arrays

A Dell EqualLogic Technical White Paper

Dell Storage Engineering
December 2014

A Dell Technical White Paper

Revisions

Date	Description
December 2014	Initial release

Table of contents

Acknowledgements

This technical white paper was produced by the following members of the Dell Storage team:

Engineering: Danilo Feroce

Editing: Margaret Boeneke

Feedback

We encourage readers of this publication to provide feedback on the quality and usefulness of this information by sending an email to SISfeedback@Dell.com.

SISfeedback@Dell.com

Executive summary

The appeal of cloud models, either public or private, is that the infrastructure, computing power and applications can be logically separated from the services they provide. This allows these models to offer greater flexibility and quicker scalability when compared to more traditional brick-based deployments.

However, not every enterprise CIO is willing to entrust part or the entirety of their business to public providers and third-party vendors, which means surrendering applications, data and businesses to the public cloud. This can be avoided by building a private cloud.

Microsoft private cloud solutions, built on Windows Server 2012 R2 Hyper-V and Microsoft System Center, are the software components required to build a dedicated environment to transform the way IT services are delivered to the end-users. Dell PowerEdge servers and Dell EqualLogic storage arrays are the hardware elements supporting this infrastructure, which provide high resiliency, easy-to-deploy features and seamless scalability thanks to the peer built-in architecture.

The primary business benefits of deploying a solution based on the above elements are:

- Faster deployment, thanks to the support of a broad set of functionalities, integrated management and self-service abilities
- Reduced risk, from validated configurations that can be implemented with confidence
- Lower cost of ownership, thanks to a cost-optimized and software-independent solution for rack system integration
- Dell advantage of configurations ready for Hyper-V virtualization with embedded/hot-swappable redundant components, multi-path solutions and storage tiering recommendations

1 Introduction

The overview presented in this paper underlines the strength of a joint solution between Microsoft and Dell for a Microsoft private cloud solution. The reference architecture is designed to provide guidance around the design principles and criteria of the storage, network and computing power when teamed with the Hyper-V technology and the Microsoft software stack of the solution.

1.1 Purpose and scope

This paper is primarily intended for IT professionals (IT managers, Solution Architects and Technologists) who are involved in defining, deploying, and managing Microsoft virtual infrastructures and who would like to investigate the benefits of using EqualLogic storage with the Microsoft Private Cloud solution. This document assumes the reader is familiar with Microsoft Windows Server 2012 R2, EqualLogic SAN operation, and Microsoft Hyper-V architecture and system administration. The scope of this paper is restricted to a local datacenter topology and does not include specific or detailed sizing information.

1.2 Terminology

The following terms are used throughout this document.

Group: Consists of one or more EqualLogic PS Series arrays connected to an IP network that work together to provide SAN resources to host servers.

Member: Identifies a single physical EqualLogic array.

Pool: A logical collection that each member (array) is assigned to after being added to a group that contributes its storage space to the pool.

Information Technology Infrastructure Library (ITIL): A set of practices focused to align IT services and business by describing processes and their relationships with people and technologies.

Microsoft Operations Framework (MOF): A series of guidelines and best practices provided to help IT professionals establish and maintain services across the IT life cycle.

Hypervisor: The software layer that manages the access to the hardware resources, residing above the hardware, and in between the operating systems, running as guests.

VHDX: File format for a Virtual Hard Disk in a Windows Hyper-V 2012/R2 hypervisor environment.

Virtual Machine (VM): An operating system implemented on a software representation of hardware resources (processor, memory, storage, network, and others). VMs are usually identified as guests in relation with the host operating system that executes the processes to allow them to run over an abstraction layer of the hardware.

Virtual network: A network consisting of virtual links as opposed to wired or wireless connections between computing devices. A virtual network is a software implementation similar to a physical switch, but with different limitations.

2 A private cloud solution by Microsoft and Dell

2.1 Definition of cloud computing

Cloud computing is an evolving paradigm with a model that provides deployment strategies and tactics to offer computing services. It is a model enabling on-demand, 24/7, convenient network access to a shared pool of configurable resources, including servers, storage, networks, applications and services.

This model features five distinguishing elements, along with three service and deployment models.

- **Broad network access:** computing capabilities are available over the network through standard mechanisms supported by a variety of client platforms.
- **On-demand self-service:** the ability to automatically provision computing capabilities as needed, without manual intervention.
- **Resource pooling:** the computing resources are pooled to serve multiple consumers and dynamically reassigned according to the consumers demand.
- **Rapid elasticity:** capabilities can be provisioned and released elastically to rapidly scale or shrink with the demand.
- **Measured service:** the cloud systems leverage a metering capability to control, optimize and charge the active consumer for the service provided.

Service models:

- **Software as a Service (SaaS):** the consumer accesses the applications shared over the network by the provider without having any knowledge or control over the infrastructure underlying the application stack.
- **Platform as a Service (PaaS):** the consumer deploys its own acquired or developed applications into the cloud infrastructure and within the boundaries and support of the provider. The cloud systems infrastructure still remains inaccessible and not under the control of the consumer.
- **Infrastructure as a Service (IaaS):** the consumer provisions processing, storage, network and other resources from the pools made available from the provider, and runs arbitrary software, both operating systems and applications.

Deployment models:

- **Private Cloud:** the cloud infrastructure is provisioned for exclusive use of a single organization, usually multiple consumers or business units. It may be owned and operated by the organization, a third party or a combination of them. It may be deployed on or off premises.
- **Public Cloud:** the cloud infrastructure is provisioned for open use by any consumer and follows the rules and chargeable model of the provider. It is hosted and managed on-premises by the provider.
- **Hybrid Cloud:** the cloud infrastructure is a mix of the two models above (private and public). They are bound by a standardized or proprietary solution to exchange data and share the applications.

2.2 Dell solution elements

Dell is committed to the next-generation dynamic datacenter and thus to private cloud. The enterprise solution presented in this paper combines PowerEdge servers, EqualLogic storage arrays and Dell Network fabric to support the Microsoft software stack required.

Compute: Dell PowerEdge servers, built on the latest CPU technologies and optimized for heavy memory workloads and I/O capacity, powering the Windows Server virtualization platform.

Network: Dell Networking provides resilient and highly available connectivity for a virtualized or converged-ready environment using Layer 2/3 Ethernet switches scaling up to 10GbE performance to sustain heavy virtualized workloads.

Storage: Dell EqualLogic provides a simplified storage management framework, based on a peer architecture, that is able to seamlessly grow on-demand from one to multiple arrays, and to maintain a highly available environment through non-disruptive firmware upgrades. The latest PS6210 Series offers enhanced storage performance and capacity for the small-to-medium enterprise by leveraging the native 10GbE iSCSI network and the support of a broad set of disk drives, spanning from the Nearline SAS drives 7.2k RPM with large capacity to the 15k RPM SAS and the SSD drives.

2.3 Microsoft solution elements

Microsoft Private Cloud solution stack is built upon two fundamental pillars for the modern datacenter.

Windows Server: is the core piece of the architecture. It powers the host hypervisor in a scalable and resilient fashion by supporting up to 64 sockets and 4TB of memory. It also provides native clustering and balancing features.

- **Hyper-V**: is the virtualization technology in Windows Server. It enables the Operating System to unleash the computing power of the underlying hardware to run multiple VMs and complex workloads in a virtualized stack.

System Center Suite: is a unified management suite for enterprise Windows environments. It allows the deployment, management, and monitoring of virtualized infrastructures across datacenters, orchestrating their provisioning, configuration, data protection and health check. The components of the suite are:

- **Orchestrator**, a workflow engine powering the creation, deployment and monitoring of resources
- **App Controller**, a web-based and scripting interface providing self-service capabilities to the application owners
- **Virtual Machine Manager**, provides virtual machine deployment and management capabilities
- **Operations Manager**, offers infrastructure and applications monitoring and diagnostics, including performance and availability of the application and services deployed
- **Service Manager**, a platform for IT service management processes such as problem resolution, change control and release management, that was inspired from MOF and ITIL frameworks
- **Data Protection Manager (DPM)**, a centralized data protection tool allowing the backup and recovery for Windows, virtual machines and applications

3 Solution overview

The solution described in this paper is built on the latest generation of Dell and Microsoft hardware and software. A set of PowerEdge rack servers powers Microsoft Windows 2012 R2 with Hyper-V technology, the back-end iSCSI SAN to provision the virtual infrastructure and to support the workloads is founded on Dell EqualLogic. Dell Network Ethernet switches offer the connectivity on both the iSCSI network and the traditional LAN/WAN IP network.

3.1 Physical system configuration

The physical components and the connections beneath the virtual infrastructure are shown in Figure 1.

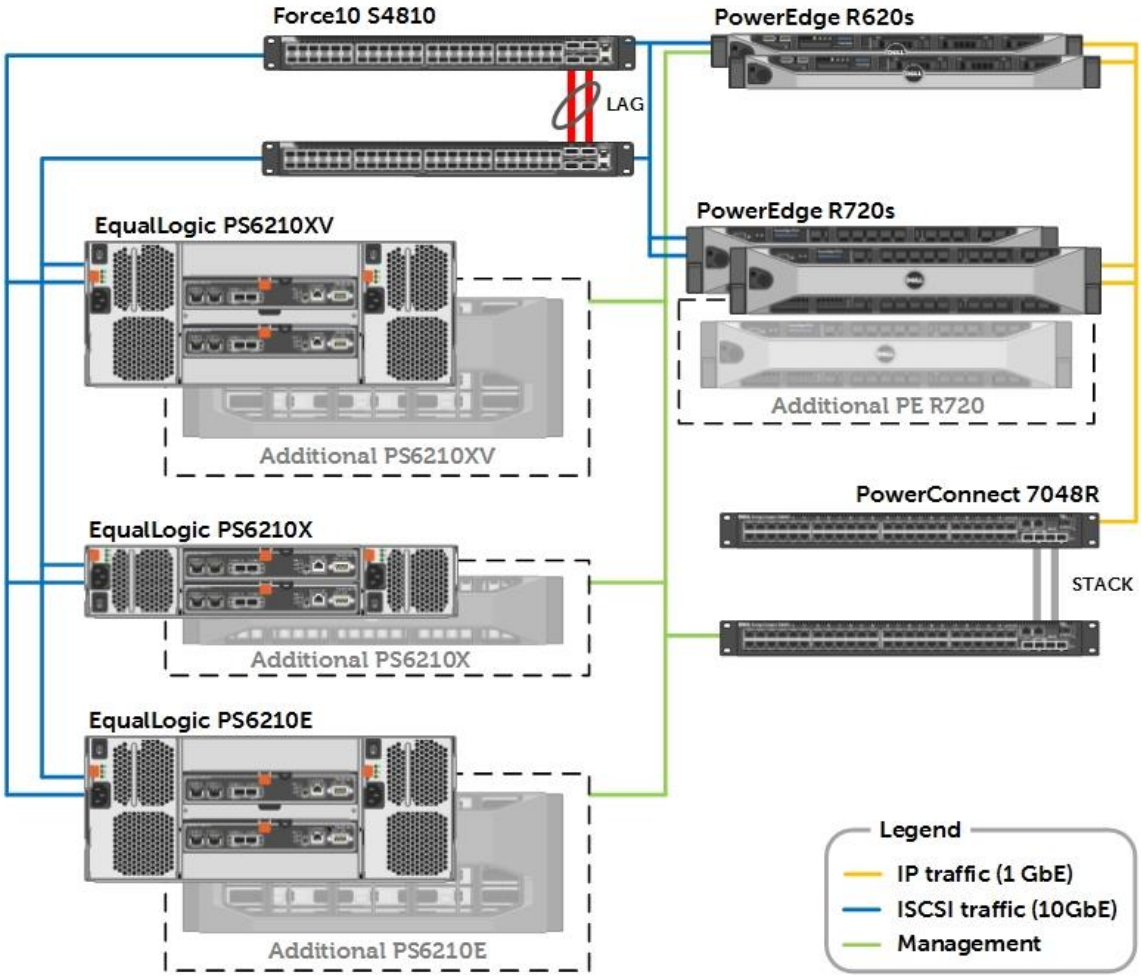

Figure 1 Physical system design for the solution components

The solution architecture was deployed on Dell rack servers with top of rack (ToR) Ethernet network switches dedicated to IP traffic (traditional client/server, management, and hypervisor communications) and to iSCSI storage access respectively. The hardware elements included in the architecture were:

- Two PowerEdge R620 rack servers that powered the hypervisors beneath the centralized management and monitoring infrastructure
- PowerEdge R720 rack servers that powered the hypervisors beneath the application/workload VMs, starting from a minimum of two
- EqualLogic iSCSI SAN provisioned with PS6210 family arrays (10GbE): starting from one PS6210XV 3.5", one PS6210X and one PS6210E arrays
- Two PowerConnect 7048R Ethernet switches to support LAN IP traffic configured in a stack
- Two Force10 S4810 Ethernet switches to support the iSCSI traffic configured with a Link Aggregation Group (LAG) consisting of two connections between the ToR S4810 switches

Note: Configuration details used in the solution infrastructure, including a hardware and software list, SAN array characteristics and physical and virtual network connections, are listed in Appendix A.

3.2 Conceptual system design

The logical elements of the infrastructure supporting the environment, their main relationships and connectivity links are represented in the conceptual diagram in Figure 2.

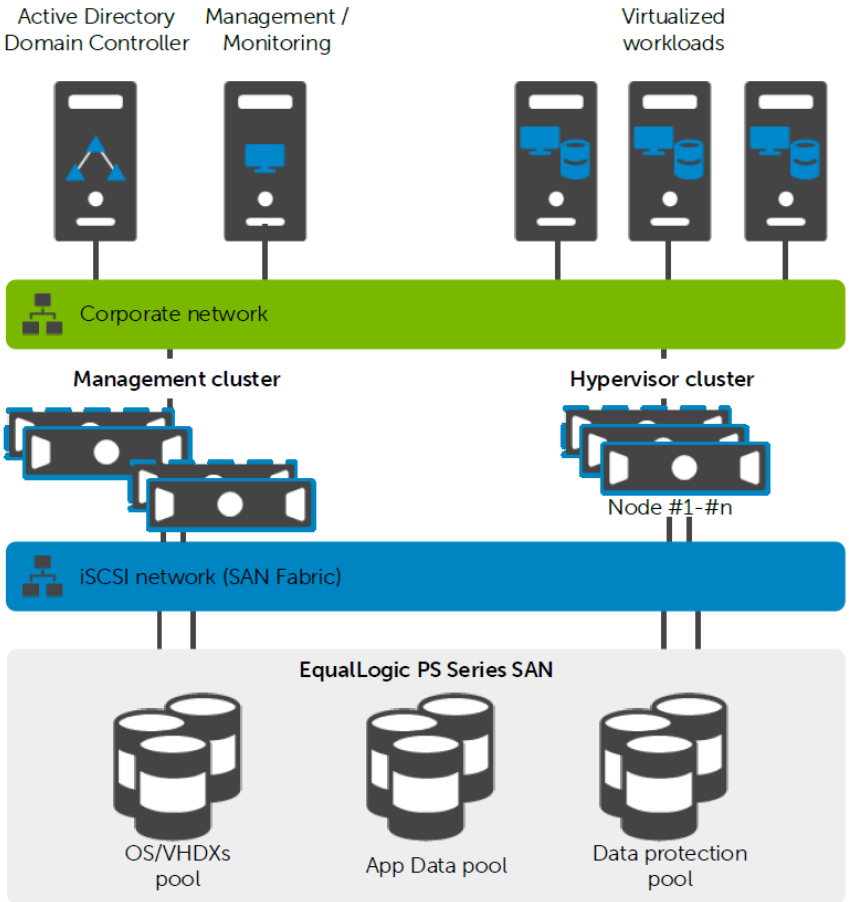

Figure 2 Conceptual system design for the solution components

The key elements of this design are:

- Single Active Directory forest, single domain
- Centralized management and monitoring with dedicated resources (both physical and virtual)
- Separated network design to maintain traffic isolation between traditional LAN and iSCSI access

3.3 Storage layout

The configuration of EqualLogic SAN arrays and the underlying volumes included:

- One EqualLogic group, configured with one PS6210XV 3.5 inch array, one PS6210X and one PS6210E
- Three storage pools, associated with each array member of the group with a one-to-one ratio
- RAID 6 policy applied as a reference configuration for the PS6210X and PS6210E arrays
- RAID10 policy applied as a reference configuration for the PS6210XV array
- One or more volumes allocated in each pool and connected to the respective server to host data, virtual machine files and backups.

A logical view of the storage allocation is shown in Figure 3.

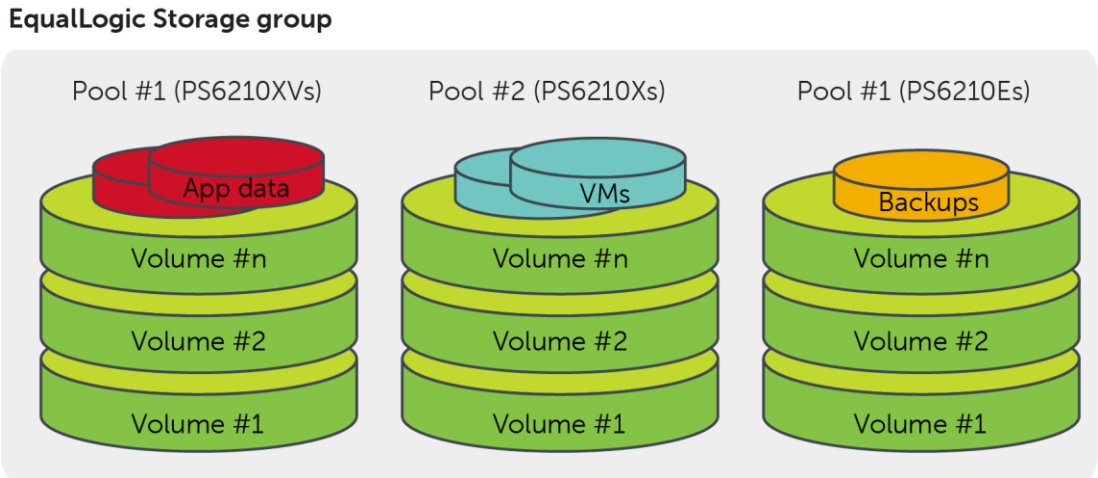

Figure 3 Storage and volumes layout

4 Solution design

Each organization has unique requirements that lead to individual ways to deploy and manage IT services, applications and levels of service. A common solution addressing multiple needs should take into consideration the most stringent requirements in order to comply with a wide set of the organization's needs.

The primary principles to conform to during the design of this solution can be summarized in this list:

- Standardized infrastructure deployment by the usage of building blocks or modular architecture
- High availability of the services or applications implemented in the virtual infrastructure
- Flexibility in pooling and rebalancing the workloads across the infrastructure
- Faster scalability to respond to increasing service demands or to pick requests
- Low cost of ownership and administration by self-service provisioning of VMs

To support and describe this reference architecture the following elements are parts of the infrastructure:

Supporting systems

Active directory and DNS must be present to allow Windows failover cluster features and System Center configuration. Both systems have native capabilities to be deployed in a resilient configuration by replicating the respective databases to the next Domain Controller (DC) or DNS server.

A minimum of two DC and two DNS servers are advised to be deployed in the environment, a greater number is subjective to the topology and size of the rest of the infrastructure.

The common best practices from Microsoft on DC/DNS deployment apply here without modifications (for example, Global Catalog configuration, DNS zone integration).

Out-of-band management

The management of each hardware component (servers, storage arrays, network switches) is routed through dedicated network connectivity (vLAN) from each device (iDRACs and management ports).

Management platform

The management and deployment components selected from the System Center suite as listed in section 2.3 are deployed within one or multiple virtual machines running on a dedicated set of hardware (PowerEdge R620s and dedicated volumes on the EqualLogic SAN).

To tolerate the failure of the hypervisor server hosting the management components, the servers are installed in a failover cluster configuration with two Hyper-V nodes:

- A dedicated high-bandwidth network connection allows the Live Migration feature for the VMs
- All management VMs consist of one or more VHDX, and are configured as highly available

- All volumes presented to the failover cluster are sourced from the storage pool #2, residing on the PS6210X array
- VM templates are configured on the Virtual Machine Manager Library, and are ready to be deployed
- Self-service VM provisioning is available to administrators with the need to delegate the deployment activities to other users or directly to the service owners
- Data protection mechanism and schedules are configured in the DPM server to backup applications data over the network (LAN)
- DPM backup targets are stored in volumes sourced from the storage pool #3, residing on the PS6210E array

Private or tenant cloud

The private virtualized infrastructure supporting the business services is entirely deployed on its own set of hardware resources (PowerEdge R720s and dedicated volumes on the EqualLogic SAN).

To tolerate the failure of an hypervisor server hosting any of the applications or services, the servers are installed in a failover cluster configuration with two Hyper-V nodes:

- A dedicated high-bandwidth network connection allows Live Migration feature for the VMs
- All management VMs consist of one or more VHDX, and are configured as highly available
- The volumes hosting the VHDX for the Operating Systems of the VMs are sourced from the storage pool #2, residing on the PS6210X array
- The volumes hosting the VHDX for the application data (database or file systems) of the VMs are sourced from storage pool #1, residing on the PS6210XV array
- The VM templates usually provide options that define the performance nature of the VM to be deployed (for example, light, medium, heavy, extra-heavy) to simplify the self-service process
- The performance nature of a template is reflected in the amount of virtual resources assigned to the VM (number of virtual CPUs, amount of virtual memory, base disk or/and extra disk resources)
- The extra storage requirement of some VMs is pre-assigned to the storage pool #1 with the intent to provide the maximum storage performance to the specific workload

Note: The exploitation of VM templates with a standard subset of virtual resources, and possibly respecting a multiplier between those resources, is a good practice to have a flexible virtual infrastructure where VMs can be rebalanced across the physical infrastructure with less risk of unpredictable saturation of the underlying computing power of the hypervisors. Nevertheless a manual configuration or customization of a deployed template is always plausible.

Computing performance scale-out

The private cloud presented in the previous section is based on a minimal two node failover cluster. This configuration provides:

- Resiliency for highly available VMs through the Live Migration capabilities

- The adequate computing power associated with the amount of physical memory and CPU/cores available in the server

Depending on the number of VMs and their resource footprints required by the services, the number of nodes in the cluster can be extended seamlessly by adding (or potentially removing) servers to the infrastructure. While the current limitation for the number of nodes in a Windows failover cluster is 32, the practical implementation also depends on the storage workload patterns run on the VMs.

Note: Do not implement a high ratio of servers per array when in presence of heavy storage workloads to avoid excessive oversubscription on the iSCSI network between server and array ports. A fully scaled failover cluster with eight nodes represents the optimal compromise when scaling-out the SAN accordingly.

Note: Maintain an equal amount of resources and physical characteristics for the newly added servers to the cluster. Scaling-out by using the same building block reduces complexity and simplifies the management of virtual resources.

Storage capacity and performance scale-out

Similarly to the computing power on the servers, the minimal SAN configuration presented includes a basic EqualLogic storage group with three arrays and three storage pools. This configuration offers the opportunity to run specific workloads on the most appropriate spindles and/or RAID policy. For particular use cases, the drives and the policies can be tailored to very unique requirements.

- Best performance with lower capacity (PS6210XV in RAID 10) for application data as databases or file systems
- Medium performance and capacity (PS6210X in RAID 6) for VM operating systems and for the management infrastructure
- Best capacity with lower performance (PS6210E in RAID 6) for large backups of data and VMs

Again, depending on the requirement of the private cloud services, the Equallogic SAN peer design allows a transparent scaling-out of the resources depending on the demand (capacity or IOPS). The current allowed configurations include a maximum of eight array members per storage pool or a combined maximum of 16 array members per storage group.

Since the proposed reference architecture includes three storage pools, a great flexibility is offered to tailor the SAN to the workloads demand in one area or another (many VMs, heavy storage workloads/data, or high retention for the backup policies).

Sizing examples

Table 1 lists a set of possible configurations developed from the previous scale-out sections.

Table 1 Examples of scale-out configurations

Configuration	Management Nodes	Private cloud nodes	PS6210XV (R10)	PS6210X (R6)	PS6210E (R6)
Basic	2	2	1 = 5.7 TB	1 = 14.8 TB	1 = 68.1 TB
Medium	2	4	2 = 11.4 TB	2 = 29.6 TB	2 = 136.2 TB
Large	2	8	3 = 17.1 TB	3 = 44.4 TB	2 = 136.2 TB
Data intensive	2	8	5 = 28.5 TB	2 = 29.6 TB	2 = 136.2 TB
VM intensive	2	8	1 = 5.7 TB	4 = 59.2 TB	2 = 136.2 TB
High retention	2	4	2 = 11.4 TB	2 = 29.6 TB	3 = 204.3 TB

A Configuration details

A.1 Hardware components

Table 2 lists the details of the hardware components used for the configuration.

Table 2 Hardware components

Component	Description
Servers	Dell PowerEdge R620 server, Firmware 2.2.3 • 2x Eight Core Intel Xeon E5-2665 Processors, 2.4 Ghz, 20M Cache • RAM 32 GB (4x 8GB) • iDRAC7 Enterprise, Firmware 1.57.57 • PERC H710 Mini RAID controller, Firmware 21.3.0-0009 • 4x 146 GB 15K SAS (2x RAID-1, stripe 1MB) • 4x Broadcom NetXtreme 5720 Quad Port 1GbE Base-T onboard, Firmware 7.10.18 • 2x Broadcom NetXtreme II 57810 Dual Port 10GbE Base-T, Firmware 7.10.18 Dell PowerEdge R720 servers, Firmware 2.2.3 • 2x Eight Core Intel Xeon E5-2665 Processors, 2.4 Ghz, 20M Cache • RAM 384 GB (24x 16GB) • iDRAC-7 Enterprise, Firmware 1. 57.57 • PERC H710 Mini RAID controller, Firmware 21.3.0-0009 • 4x 146 GB 15K SAS (2x RAID-1, stripe 1MB) • 4x Broadcom NetXtreme 5720 Quad Port 1GbE Base-T onboard, Firmware 7.10.18 • 2x Broadcom NetXtreme II 57810 Dual Port 10GbE Base-T, Firmware 7.10.18
Network	2x Dell Force10 S4810 Ethernet switches, Firmware 9.2.0.0 • 48x 10GbE interfaces • 4x 40GbE interfaces • Installed top of the rack • Connected by 2x 40GbE redundant uplinks (LAG) 2x Dell PowerConnect 7048R Ethernet switch, Firmware 5.1.3.7 • 48x 1GbE interfaces • 4x 10GbE interfaces • Installed top of the rack • Connected by 2x16GbE redundant uplinks (STACK)

Storage	Dell EqualLogic PS6210E • Storage Array Firmware 7.0.7 • Dual 1 port 10GbE controllers • Dual 1 port 1GbE management interface • 24x 4TB 7.2K 3.5" NL-SAS disk drives, raw capacity 96 TB Dell EqualLogic PS6210X • Storage Array Firmware 7.0.7 • Dual 1 port 10GbE controllers • Dual 1 port 1GbE management interface • 24x 900GB 10K 2.5" SAS disk drives, raw capacity 21.6 TB Dell EqualLogic PS6210XV 3.5" • Storage Array Firmware 7.0.7 • Dual 1 port 10GbE controllers • Dual 1 port 1GbE management interface • 24x 600GB 15K 3.5" SAS disk drives, raw capacity 14.4 TB

A.2 Software components

The environment built for the reference architecture described in this paper included the following software components:

- Hypervisor: Windows Server 2012 R2 with Hyper-V on every physical host
- Dell OpenManage Server Administrator on every physical host
- Broadcom Advanced Control Suite on every physical host
- Operating System: Windows Server 2012 R2 on every VM
- Dell EqualLogic Multi-pathing Extension Module to provide Dell MPIO access to the back-end SAN on the hypervisor directly accessing the SAN (host initiator)
- Dell EqualLogic SAN Headquarters to monitor the health and performance of the SAN
- Active Directory Domain Services and DNS Server roles for the domain controller VM
- Microsoft SCVMM for the management VM

Table 3 lists the details of the software components used for the configuration.

Table 3 Software components

Component	Description
Operating Systems	Host servers: • Microsoft Windows Server 2012 R2 Datacenter Edition with Hyper-V • Dell OpenManage Server Administrator 7.4.0.2 • Broadcom Advanced control Suite 4 (version 16.4.3.0) • Dell EqualLogic Host Integration Toolkit 4.7.1 • MPIO enabled using EqualLogic DSM for Windows Guest VMs: • Microsoft Windows Server 2012 R2 Datacenter Edition

Component	Description
Applications	Microsoft System Center 2012 Virtual Machine Manager R2
Monitoring tools	Dell EqualLogic SAN Headquarters 3.0.1 Microsoft Performance Monitor from the Windows Operating System

A.3 Network configuration

Two physical networks provide full isolation between regular IP traffic and iSCSI data storage traffic. Also, each regular IP network is segregated from the others by VLANs with tagged traffic. In order to achieve network resiliency to hardware faults, at least two physical switches are linked for the iSCSI data storage network using redundant uplinks (LAG) between the switches. Some relevant configuration aspects are:

- Flow control enabled for every port on S4810 switches
- Rapid Spanning Tree Protocol enabled for every edge port on S4810 switches
- Jumbo frames enabled for every port on S4810 and 7048R switches

Table 4 and Table 5 summarize the aspects of the physical and logical networks implemented in the reference architecture, and their purpose.

Table 4 Network configuration: network switch, purpose, and networks

Network Switch	Placement	Purpose	VLAN ID
PowerConnect 7048R	Top of rack	IP Traffic - LAN	100
		IP Traffic - Management	200
Force10 S4810 #1	Top of rack	iSCSI data storage traffic	1 (default)
Force10 S4810 #1	Top of rack	LiveMigration / Cluster communication	300
Force10 S4810 #2	Top of rack	iSCSI data storage traffic	1 (default)
Force10 S4810 #2	Top of rack	LiveMigration / Cluster communication	300

Table 5 Network configuration: host to switch connections

Server	Interface	NIC port	Purpose	
PowerEdge R620	BCM5720 #1	1x 1GbE	LAN and Management	IP traffic
	BCM5720 #2	1x 1GbE	LAN and Management	
	BCM5720 #3	1x 1GbE	VMs traffic	

Server	Interface	NIC port	Purpose	
	BCM5720 #4	1x 1GbE	VMs traffic	
	BCM57810 #1	1x 10GbE	SAN management and monitoring (guest VM)	iSCSI data storage traffic
	BCM57810 #2	1x 10GbE		
	BCM57810 #3	1x 10GbE	Live Migration / Cluster communication	IP traffic
	BCM57810 #4	1x 10GbE		
	Total ports = 8 (4 onboard 1GbE, 4 slot 10GbE)			
PowerEdge R720	BCM5720 #1	1x 1GbE	LAN and Management	IP traffic
	BCM5720 #2	1x 1GbE	LAN and Management	
	BCM5720 #3	1x 1GbE	VMs traffic	
	BCM5720 #4	1x 1GbE	VMs traffic	
	BCM57810 #1	1x 10GbE	SAN access (host initiator)	iSCSI data storage traffic
	BCM57810 #2	1x 10GbE		
	BCM57810 #3	1x 10GbE	Live Migration / Cluster communication	IP traffic
	BCM57810 #4	1x 10GbE		
	Total ports = 8 (4 onboard 1GbE, 4 slot 10GbE)			

B Additional resources

Support.dell.com is focused on meeting your needs with proven services and support.

DellTechCenter.com is an IT Community where you can connect with Dell Customers and Dell employees for the purpose of sharing knowledge, best practices, and information about Dell products and installations.

Referenced or recommended Dell publications:

- Dell EqualLogic Configuration Guide:
  http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/19852516/download.aspx

- Dell EqualLogic Storage with Heterogeneous Virtualized Workloads on Microsoft Windows Server 2012 with Hyper-V:
  http://en.community.dell.com/techcenter/extras/m/white_papers/20437010/download.aspx

- Automation and Integration with MS System Center Virtual Machine Manager 2012 SP1 and Dell EqualLogic Storage:
  http://en.community.dell.com/techcenter/extras/m/white_papers/20437936/download.aspx

Referenced or recommended Microsoft publications:

- Microsoft Private Cloud platform:
  http://www.microsoft.com/en-us/server-cloud/solutions/virtualization-private-cloud.aspx

Referenced or recommended additional publications:

- The NIST Definition of Cloud Computing
  http://www.nist.gov/manuscript-publication-search.cfm?pub_id=909616