REFERENCE ARCHITECTURE

Dell EMC Ready System for VDI on VxRail

Integration of Citrix XenDesktop with Dell EMC VxRail appliance

Abstract

A Reference Architecture for integrating Dell EMC VxRail Appliance and Citrix XenDesktop brokering software to create virtual application and virtual desktop environments on 14th generation Dell EMC PowerEdge Servers.

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Acknowledgements

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Executive summary

This document provides the reference architecture for integrating the Dell EMC VxRail™ Appliances and Citrix® XenDesktop™ software to create virtual application and virtual desktop environments.

The Dell EMC VxRail Appliance is a hyper-converged solution that combines storage, compute, networking, and virtualization using industry-proven Dell EMC PowerEdge™ server technology. By combining the hardware resources from each appliance into a shared-everything model for simplified operations, improved agility, and greater flexibility, Dell EMC and VMware together deliver simple, cost-effective solutions for enterprise workloads.

Citrix XenDesktop provides a complete end-to-end virtualization solution delivering Microsoft® Windows™ virtual desktops or server-based hosted shared sessions to users on a wide variety of endpoint devices.

1 Introduction

This document addresses the design, configuration and implementation considerations for the key components of the architecture required to deliver virtual desktops via Citrix XenDesktop on the Dell EMC VxRail Appliance 4.5 with vSphere™ 6.5 and VMware vSAN™ 6.6.

1.1 Scope

Relative to delivering the virtual desktop environment, the objectives of this document are to:

- Define the detailed technical design for the solution.
- Define the hardware requirements to support the design.
- Define the constraints, which are relevant to the design.
- Define relevant risks, issues, assumptions and concessions – referencing existing ones where possible.
- Provide a breakdown of the design into key elements such that the reader receives an incremental or modular explanation of the design.
- Provide scaling component selection guidance.

1.2 What's new

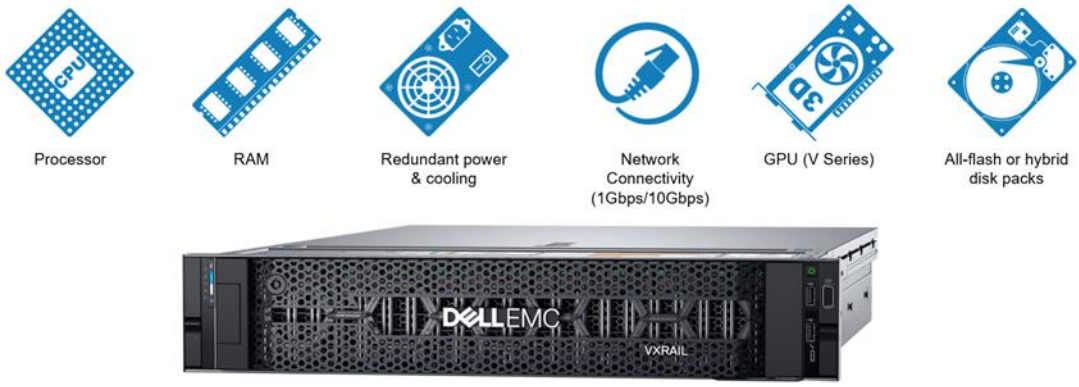
- Introduce Dell EMC VxRail Appliance on 14th generation servers
- Introduce Hybrid & All-Flash configuration for Dell EMC VxRail Appliances
- Introduce VDI optimized Dell EMC VxRail Appliance V Series configurations

2 Solution Architecture Overview

2.1 Introduction

Dell EMC VDI solutions provide a number of deployment options to meet your desktop virtualization requirements. Our solutions provide a compelling desktop experience to a range of employees within your organization from task workers to knowledge workers to power users. The deployment option for this Dell EMC VDI solution uses Citrix Machine Creation Services (MCS) (Random/Non-Persistent).

2.2 Dell EMC VxRail Appliance overview



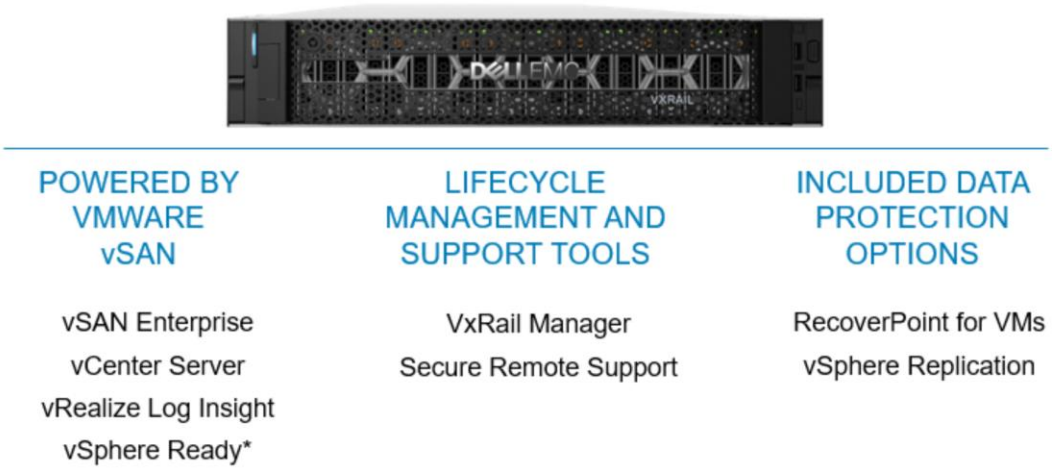
The Dell EMC VxRail Appliance is a very powerful Hyper Converged Infrastructure Appliance (HCIA) delivered in 1U or 2U rack building blocks. It is built on VMware vSAN technology within VMware VSphere and further enabled using Dell EMC software. The appliance allows the seamless addition and management of additional nodes to the appliances from the minimum supported 3 nodes up to 64 nodes.

The Dell EMC VxRail Appliance platforms are equipped with new Intel® Xeon™ Scalable Processors. A cluster can be deployed with as few as 3 nodes providing an ideal environment for small deployments or POCs. To achieve full vSAN HA, the recommended starting block is 4 nodes. The VxRail Appliance can now support storage-heavy workloads with storage dense nodes, graphics-heavy VDI workloads with GPU hardware and entry-level nodes for remote and branch office environments.

The VxRail Appliance allows customers to start small and scale as their requirements increase. Single-node scaling and low-cost entry point options give you the freedom to buy just the right amount of storage and compute, whether just beginning a project or adding capacity to support growth. A single node VxRail V Series appliance can be configured with 8 to 28 CPU cores per node, support a maximum of 40 TB raw storage with a hybrid configuration or 76 TB with the all-flash option. A 64-Node all-flash cluster delivers a maximum of 3,584 cores and 4,864 TB of raw storage.

2.2.1 What's included in the Dell EMC VxRail 4.5 Appliance

A full suite of capabilities is included with the Dell EMC VxRail 4.5 Appliance at no additional cost.



Powered by VMware vSAN:

VxRail Appliance contains the following software from Dell EMC and VMware:

- vSAN
- vCenter
- ESXi
- vRealize Log Insight

Lifecycle Management and Support Tools

VxRail Appliance Manager:

This is the primary deployment and element manager interface which delivers automation, lifecycle management and serviceability. VxRail Manager simplifies the entire lifecycle from deployment, to management, to scaling, to maintenance. Upgrades are completed with a single click via the VxRail Appliance Manager interface, as well as monitoring via dashboard for health, events and physical views.

Secure Remote Services (ESRS):

ESRS is a highly secure, two-way remote connection between your VxRail Appliance product and Dell EMC technical support. The automated health checks to ensure your environment is at optimal performance and with remote issue analysis and diagnosis, and remote delivery of Dell EMC's award-winning service and support.

Included Data Protections Options

RecoverPoint for VMs

Dell EMC RecoverPoint for Virtual Machines, a member of the RecoverPoint family, redefines data protection for VMware virtualized environments. It protects Virtual Machines (VM) at VM level granularity with local and remote replication for recovery to any Point-in-Time (PiT). It supports synchronous and asynchronous replication over any distance with efficient WAN bandwidth utilization, reducing network costs up to 90%.

RecoverPoint for VMs simplifies disaster recovery, disaster recovery testing and operational recovery with built-in orchestration and automation capabilities directly accessible from VMware vCenter. It provides a reliable and repeatable automated DR workflow that increases customer's data protection and recovery operational efficiencies. This fully virtualized data protection product is built on the robust RecoverPoint engine, the proven market leader in replication and disaster recovery.

For more information on RecoverPoint is located here.

vSphere Replication

VMware vSphere Replication is a hypervisor-based, asynchronous replication solution for vSphere virtual machines. It is fully integrated with VMware vCenter Server and the vSphere Web Client. vSphere Replication delivers flexible, reliable and cost-efficient replication to enable data protection and disaster recovery for all virtual machines in your environment.

For more information on VSphere Replication visit here.

Enhanced Protection (optional):

Data Protection Suite for VMware

Dell EMC Data Protection Suite for VMware provides organizations with industry-leading data protection to meet the Recovery Point Objectives (RPO) of your VMware servers and applications. The Suite provides backup and recovery, continuous data protection for any point-in-time recovery, backup to the cloud, monitoring and analysis, as well as search capabilities. The Suite supports virtual and physical servers along with protection of network-attached storage (NAS).

For more information on Data Protection Suite for VMware visit here.

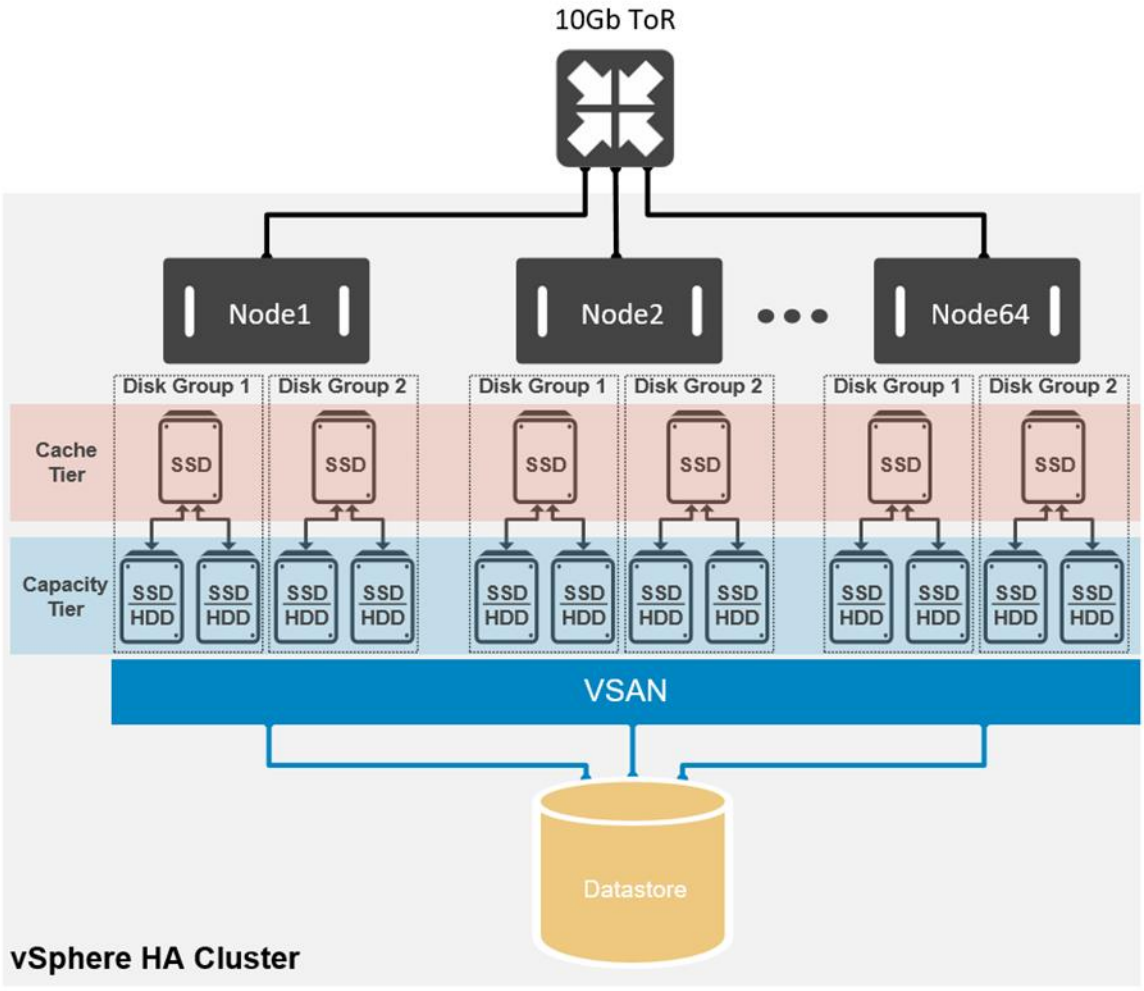
Data Domain Virtual Edition (DDVE)

Bring efficient, reliable data protection to remote and branch office, entry-level, and cloud environments with Dell EMC Data Domain Virtual Edition. DD VE is the software-defined version of Dell EMC Data Domain, the world’s most trusted protection storage. Benefit from core Data Domain features that include data deduplication, replication, data integrity, and encryption.

DDVE gives you flexibility with a virtual appliance that runs on your hardware, or your choice of AWS or Azure, and works with your existing backup, archiving and enterprise applications. Whatever your needs, Data Domain can help you meet your backup, archive, and disaster recovery requirements.

For more information on DDVE visit here.

2.3 Software Defined Storage (vSAN)



VMware vSAN is software-defined storage solution fully integrated into vSphere. Once enabled on a cluster, all disk devices presented to the hosts are pooled together to create a shared data store that will be accessible by all hosts in the VMware vSAN cluster. Virtual machines can then be created and a storage policy can be assigned to them. The storage policy will dictate availability / performance and sizing.

From a hardware perspective, at least three ESXi hosts (four recommended) are required for the vSAN cluster. Each host will need at least one SSD and one HDD. In hybrid configurations, the SSD acts as a read cache (70%) and a write buffer (30%). The read cache keeps a list of commonly accessed disk blocks and the write cache behaves as a non-volatile write buffer. It is essential to the performance of the vSAN as all I/O goes to the SSD first. The higher the performance of the disks then the better the performance of your virtual machines. It's important to determine the number of simultaneous write operations that a particular SSD is capable of sustaining in order to achieve adequate performance.

In all-flash configurations, the cache tier is dedicated 100% to writes, allowing all reads to come directly from the capacity tier. This model allows the cache device to protect the endurance of the capacity tier.

All virtual machines deployed to vSAN have an availability policy (Failures to Tolerate) setting that ensures at least one additional copy of the virtual machine data is available; this includes the write cache contents. When

a write is initiated by the VM then it is sent to both the local write cache on the owning host and also to the write cache on the remote hosts. This ensures we have a copy of the in-cache data in the event of a host failure and no data will get corrupted. If a block is requested and not found in the read cache, the request is directed to the HDD.

Magnetic hard disk drives (referred to as HDDs from here on) have two roles in vSAN. They make up the capacity of the VMware vSAN data store as well as making up components for a stripe width. SAS and NL-SAS are supported.

VMware recommends configuring 10% of projected consumed capacity of all VMDKs space as SSD storage on the hosts. If a higher ratio is required, then multiple disk groups (up to 4) will have to be created as there is a limit of 1 cache SSD per disk group.

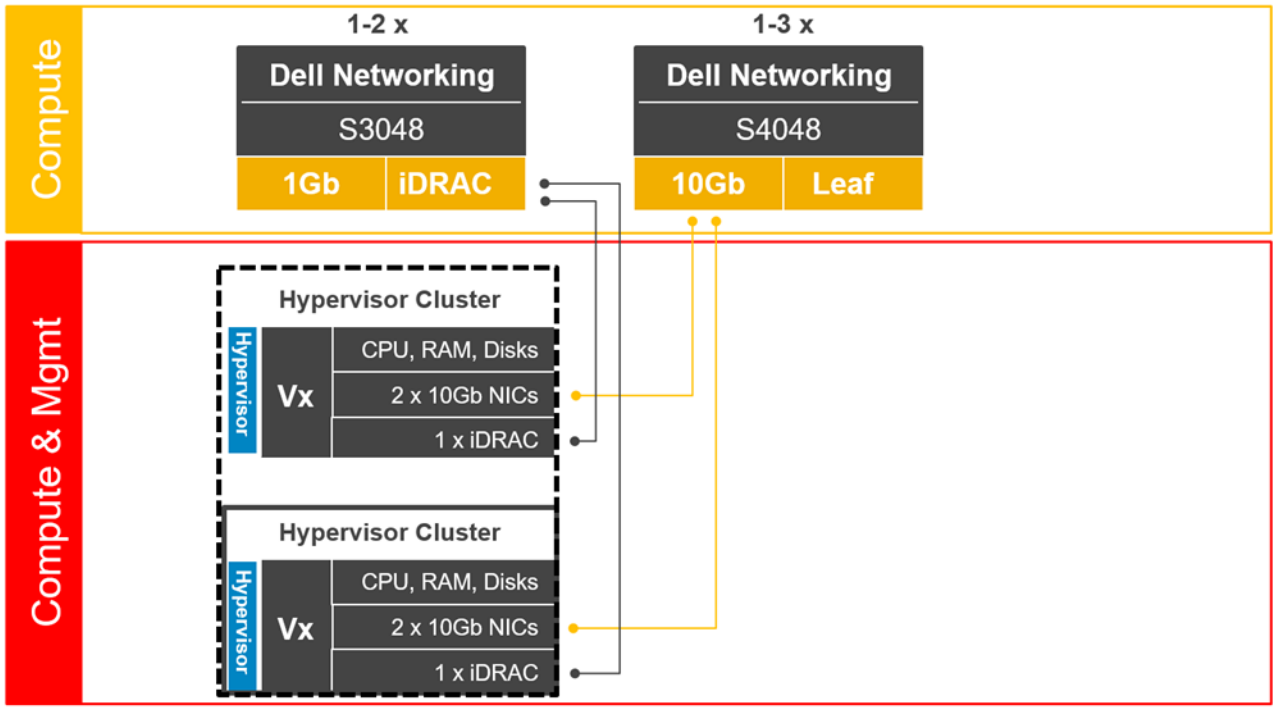
vSAN implements a distributed RAID concept across all hosts in the cluster, so if a host or a component within a host (e.g. an HDD or SSD) fails then virtual machines still have a full complement of data objects available and can continue to run. This availability is defined on a per-VM basis through the use of VM storage policies.

vSAN 6.x provides two different configuration options, a hybrid configuration that leverages flash-based devices for the cache tier and magnetic disks for the capacity tier, and an all-flash configuration. This delivers enterprise performance and a resilient storage platform. The all-flash configuration uses flash for both the cache tier and capacity tier.

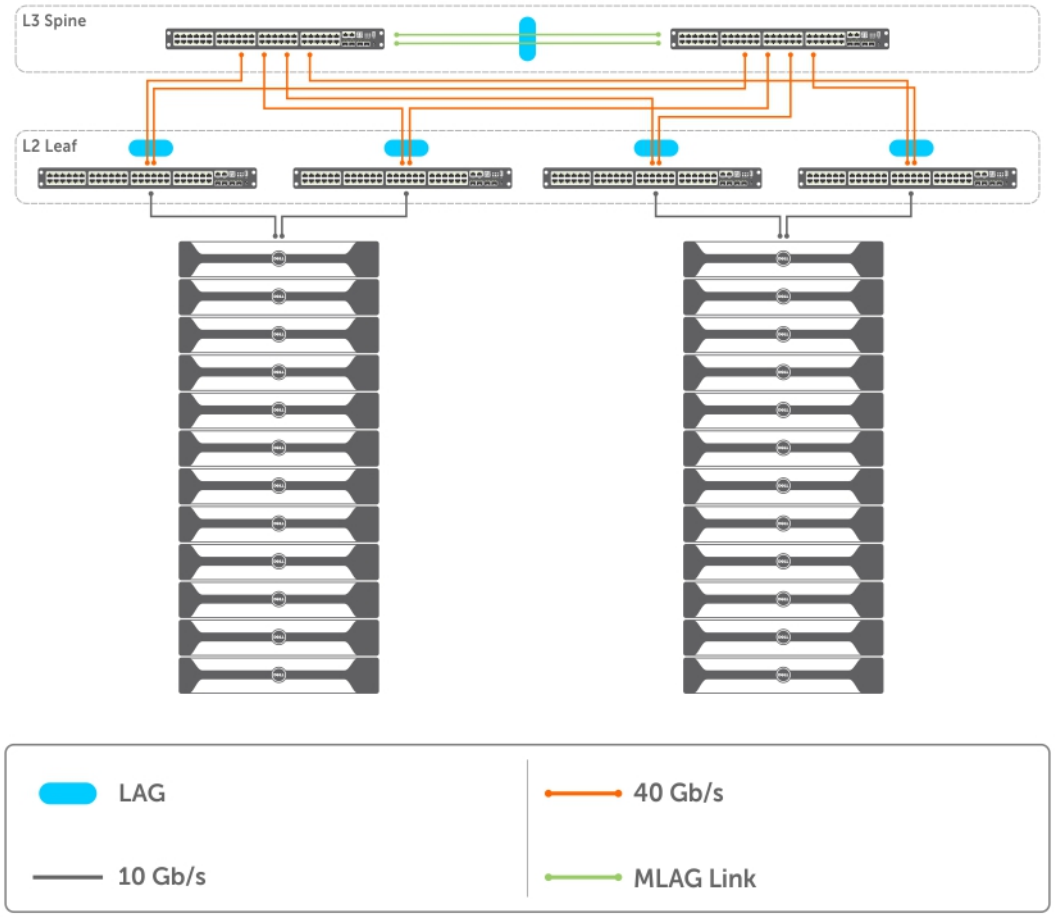
2.4 Dell EMC VxRail Appliance – VDI solution architecture

2.4.1 Networking

Designed for true linear scaling, Dell EMC VxRail Appliance series leverages a Leaf-Spine network architecture. A Leaf-Spine architecture consists of two network tiers: an L2 Leaf and an L3 Spine based on 40GbE and non-blocking switches. This architecture maintains consistent performance without any throughput reduction due to a static maximum of three hops from any node in the network.



The following figure shows a design of a scale-out Leaf-Spine network architecture that provides 20 GB active throughput from each node to its Leaf and scalable 80 GB active throughput from each Leaf to Spine switch providing scale from 3 VxRail Appliance nodes to 64 without any impact to available bandwidth:

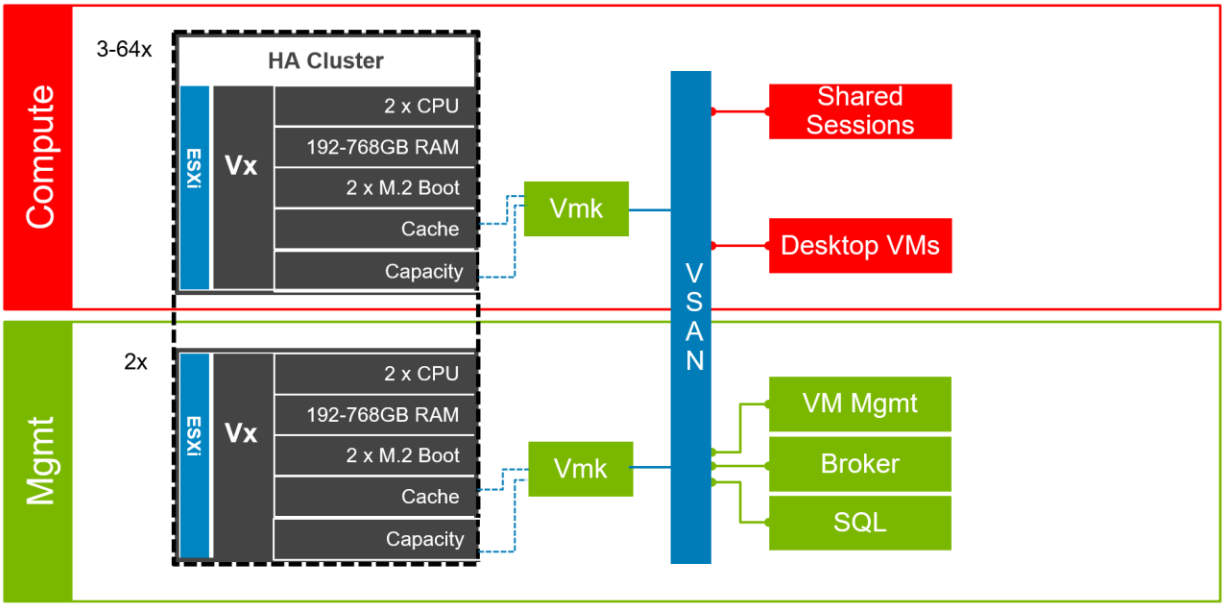


The best practices guide for VxRail Appliance with S4048-ON is located here.

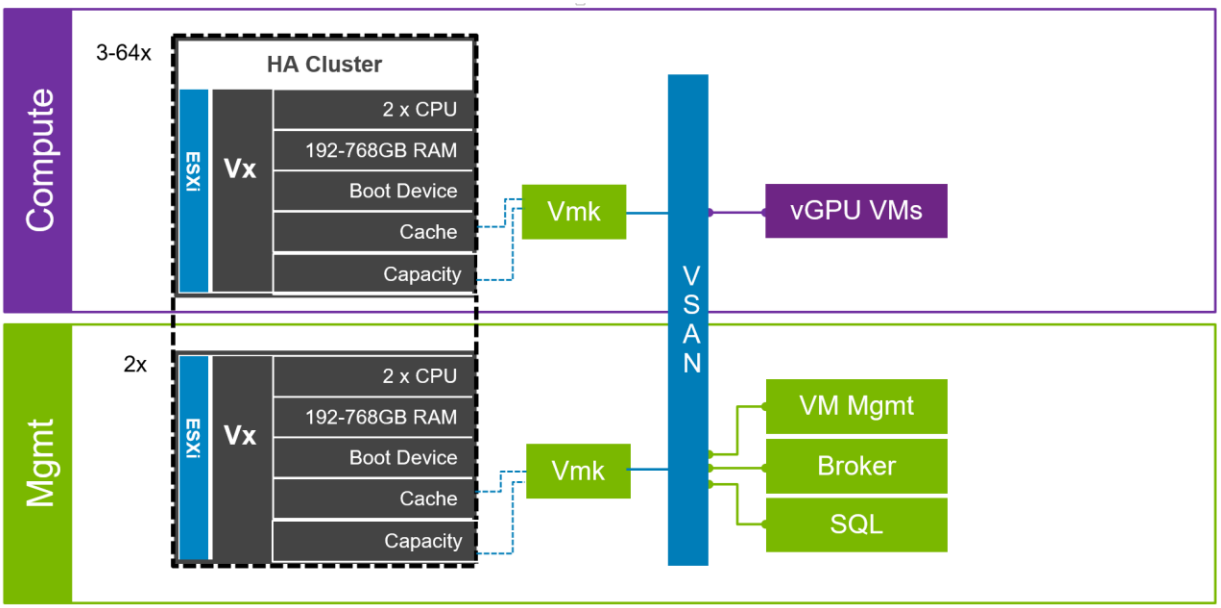
2.4.2 VxRail Appliance – Enterprise solution pods

The compute, management and storage layers are converged into a single Dell EMC VxRail Appliance server cluster, hosting VMware vSphere. The recommended boundaries of an individual cluster are based on number of the nodes supported for vSphere 6.5 which is 64.

Dell recommends that the VDI management infrastructure nodes be separated from the compute resources, in this configuration both management and compute are in the same vSphere HA Cluster. Optionally, the management node can be used for VDI VMs as well with an expected reduction of 30% for these nodes only. The 30% accounts for the amount of resources needed to be reserved for management VMs so this needs to be factored in when sizing. Compute hosts can be used interchangeably for XenDesktop or RDSH as required.



High-performance graphics capabilities come with VxRail Appliance V Series platform and provide a superior user experience with vSphere 6 and NVIDIA GRID vGPU technology.



3 Hardware components

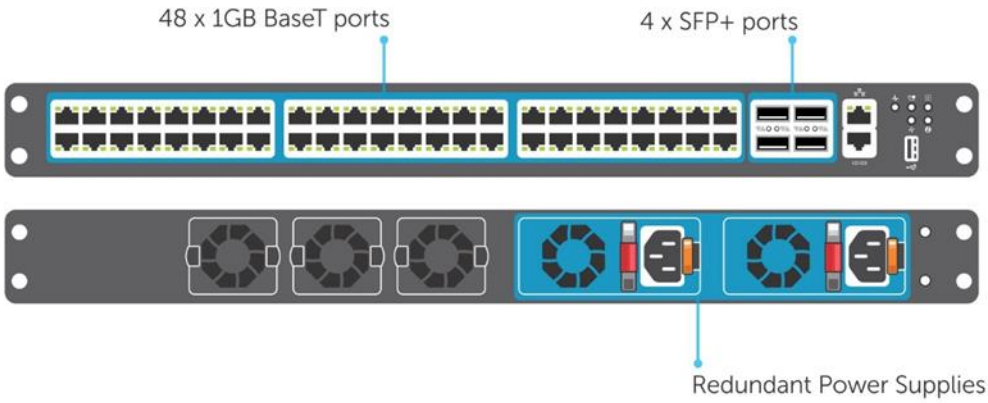
3.1 Network

The following sections contain the core network components for the Dell Wyse Datacenter solutions. General uplink cabling guidance to consider in all cases is that TwinAx is very cost effective for short 10 Gb runs and for longer runs use fiber with SFPs.

3.1.1 Dell Networking S3048 (1GbE ToR switch)

Accelerate applications in high-performance environments with a low-latency top-of-rack (ToR) switch that features 48 x 1GbE and 4 x 10GbE ports, a dense 1U design and up to 260Gbps performance. The S3048-ON also supports Open Network Installation Environment (ONIE) for zero-touch installation of alternate network operating systems.

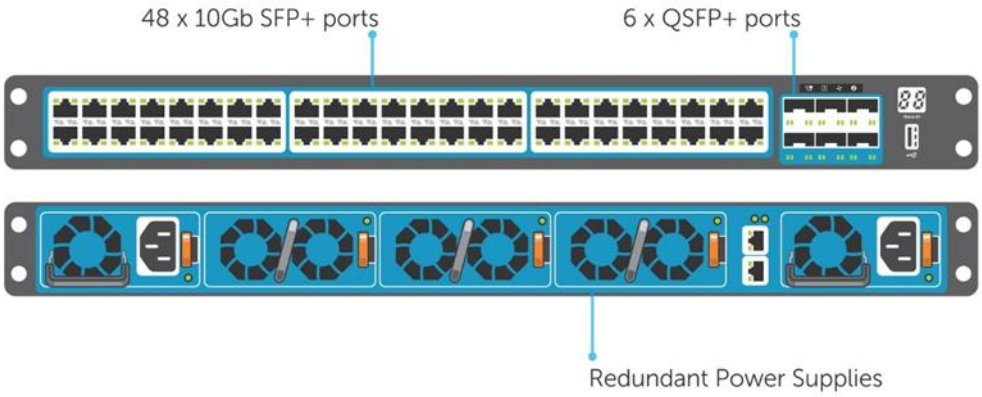
Model	Features	Options	Uses
Dell Networking S3048-ON	48 x 1000BaseT 4 x 10Gb SFP+ Non-blocking, line-rate performance 260Gbps full-duplex bandwidth 131 Mbps forwarding rate	Redundant hot-swap PSUs & fans VRF-lite, Routed VLT, VLT Proxy Gateway User port stacking (up to 6 switches) Open Networking Install Environment (ONIE)	1Gb connectivity (iDRAC)



3.1.2 Dell Networking S4048 (10 GbE ToR switch)

Optimize your network for virtualization with a high-density, ultra-low-latency ToR switch that features 48 x 10GbE SFP+ and 6 x 40GbE ports (or 72 x 10GbE ports in breakout mode) and up to 720Gbps performance. The S4048-ON also supports ONIE for zero-touch installation of alternate network operating systems.

Model	Features	Options	Uses
Dell Networking S4048-ON	48 x 10Gb SFP+ 6 x 40Gb QSFP+	Redundant hot-swap PSUs & fans	10Gb connectivity
	Non-blocking, line-rate performance	72 x 10Gb SFP+ ports with breakout cables	
	1.44Tbps bandwidth	User port stacking (up to 6 switches)	
	720 Gbps forwarding rate	Open Networking Install Environment (ONIE)	
	VXLAN gateway support		



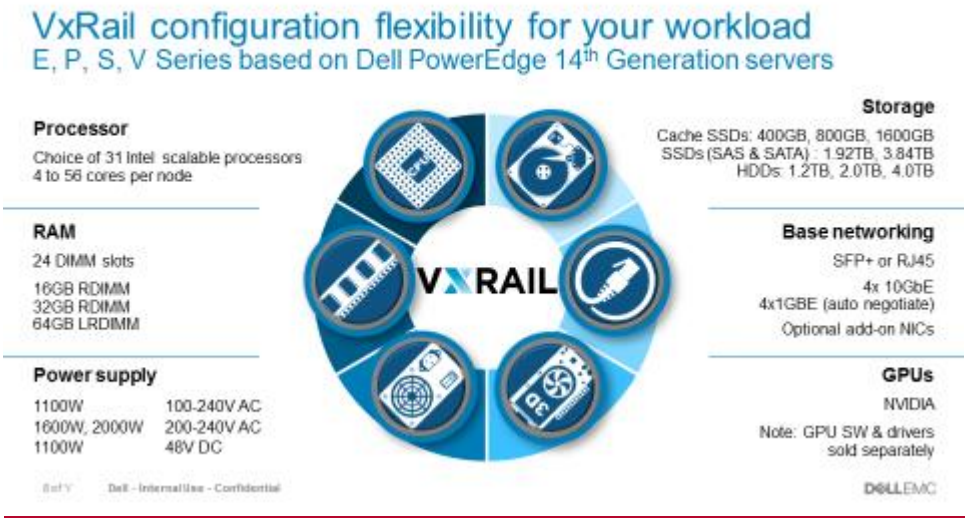
For more information on the S3048, S4048 switches and Dell Networking, please visit this link.

3.2 Dell EMC VxRail Appliance configurations

The Dell EMC VxRail Appliance has multiple platform configuration options. This Reference Architecture focuses primarily on the VDI optimized V Series platform, but this section describes the other optimized platform configuration options that are also available. The platform configurations are listed in the table below, and there are Hybrid and All-flash variants of each platform. For example, the VxRail V570 is the Hybrid configuration option and the V570F is the All-flash version.

Platform	Description	Configurations	Form Factor
E Series	Entry Level	All-Flash & Hybrid	1U1N
V Series	VDI Optimized	All-Flash & Hybrid	2U1N
P Series	Performance Optimized	All-Flash & Hybrid	2U1N
S Series	Storage Dense	Hybrid	2U1N

There are multiple possibilities with each VxRail Appliance configuration, 4 x 10GbE now supported with the 14th generation VxRail Appliance release and 1600W & 2000W power supply options.



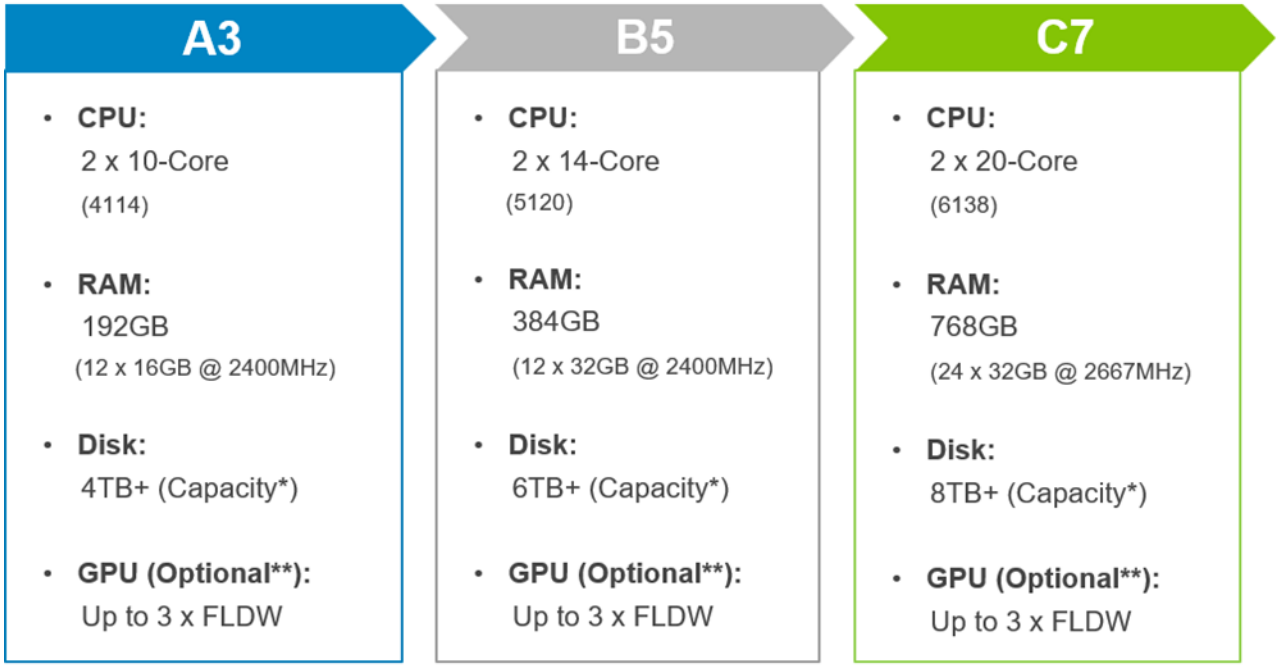
New with Dell EMC PowerEdge 14th-generation (14G) servers is the Boot Optimized Storage Solution (BOSS). The PowerEdge Engineering developed a simple, cost-effective way of meeting this customer need. The Boot Optimized Storage Solution uses redundant SATA SSD devices instead of a SATADOM to house the OS, and utilizes a two-port SATA Hardware RAID controller chip to provide Hardware RAID 1 and pass-through capabilities. The BOSS offers the same performance and better resiliency than the SATADOM architecture, and is used in all 14th generation VxRail series models. By consolidating the SSDs and controller chip on a single PCIe adapter card, the solution frees up an additional drive slot for data needs.

3.3 Dell EMC VxRail Appliance V Series VDI-optimized configurations

The VDI-optimized 2U/1Node appliance with GPU hardware for graphics-intensive desktop deployments. The V Series can be configured with or without GPUs, then added at a later date.

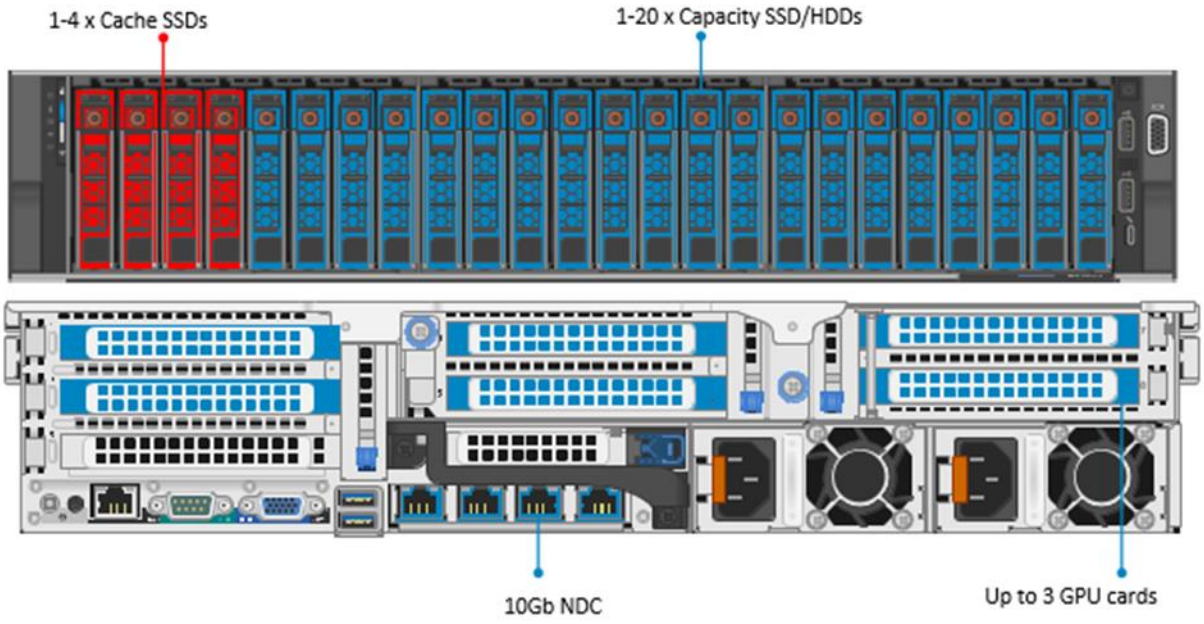
The VxRail Appliance family, optimized for VDI, has been designed and arranged in three top-level overarching configurations which apply to the available physical platforms showcased below.

- The A3 configuration is perfect for small scale, POC or low density, cost-conscience environments.
- The B5 configuration is geared toward larger scale general purpose workloads, balancing performance and cost-effectiveness.
- The C7 is the premium configuration offering an abundance of high-performance features and tiered capacity that maximizes user density.



3.3.1 VxRail V570/V570F

The VxRail V570 is a 2U platform with a broad range of configuration options. Each appliance comes equipped with dual CPUs, up to 28 cores per CPU, and up to 1.5TB of high-performance RAM. The M.2-based BOSS module is used to boot ESXi, supports up to 24 x 2.5" SAS disks, and the appliance can be outfitted with 3 x M60 NVIDIA or 2 x M10 double-wide GPU accelerators. The V series also comes with 2000W power supplies to service the higher wattage requirements of the GPUs. Each platform can be outfitted with SFP+ or RJ45 (designated as BaseT) NICs. The capacity SSD/HDDs need to be placed in Slots 1-19 and cache SSDs in 20-24.



3.3.1.1 V570/V570F-A3 Configuration

The V570/V570F-A3 configuration consists of 2 x 10 core CPUs with 192GB of memory. There are two diskgroups in this configuration, which consists of 1 x Cache SSD and 1 x Capacity SSD/HDD per diskgroup. The cache disks are populated in slots 20 & 21 and the capacity disks are in slots 0 & 1.

V570	A3
CPU	2 x Intel Xeon Silver 4114 (10C, 2.2GHz)
Memory	12 x 16GB 2667MT/s RDIMMs **Effective speed: 2400MT/s @ 192GB**
Storage Ctrls	PERC HBA330 – no RAID
Boot Device	2 x 240GB M.2 BOSS in RAID1
Storage	64GB SD Module **(PowerTools)** 2 x 400GB SSD 2.5" **(Cache)** 2 x 1.8TB HDD 2.5" **(Capacity-Hybrid)** **Or** 2 x 1.92TB SSD 2.5" **(Capacity-AF)**
Network	Intel X710 QP 10Gb SFP(NDC)
iDRAC	iDRAC9 Enterprise
Power	2 x 2000W PSUs

3.3.1.2 V570/V570F-B5 Configuration

The V570/V570F-B5 configuration consists of 2 x 14 core CPUs with 384GB of memory. There are two diskgroups in this configuration, which consists of 1 x Cache SSD and 4 x Capacity SSD/HDD per diskgroup. The cache disks are populated in slots 20 & 21 and the capacity disks are in slots 0,1,2 & 3.

V570	B5
CPU	2 x Intel Xeon Gold 5120 (14C, 2.2GHz)
Memory	12 x 32GB 2667MT/s RDIMMs **Effective speed: 2400MT/s @ 384GB**
Storage Ctrls	PERC H330 – no RAID
Boot Device	2 x 240GB M.2 BOSS in RAID1
Storage	2 X 64GB SD Module **(PowerTools)** 2 x 400GB SSD 2.5" **(Cache)** 4 x 1.8TB HDD 2.5" **(Capacity-Hybrid)** **Or** 4 x 1.92TB SSD 2.5" **(Capacity-AF)**
Network	Intel X710 QP 10Gb SFP(NDC)
iDRAC	iDRAC9 Enterprise
Power	2 x 1100W PSUs

3.3.1.3 V570/V570F-C7 Configuration

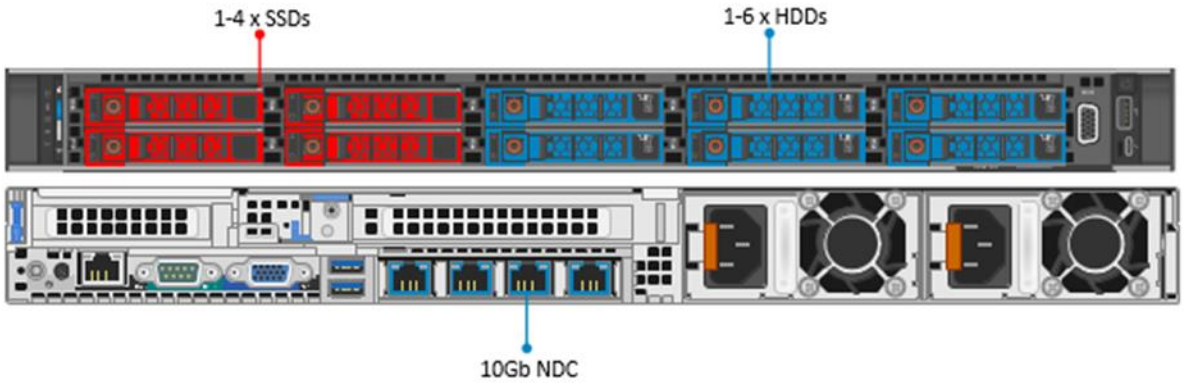
The V570/V570F-C7 configuration consists of 2 x 20 core CPUs with 768GB of memory. There are two diskgroups in this configuration, which consists of 1 x Cache SSD and 6 x Capacity SSD/HDD per diskgroup. The cache disks are populated in slots 20 & 21 and the capacity disks are in slots 0,1,2,3,4 & 5.

V570	C7
CPU	2 x Intel Gold 6138 (20C, 2.0GHz)
Memory	24 x 32GB 2667MT/s RDIMMs **Effective speed: 2667MT/s @ 768GB**
Storage Ctrls	PERC HBA330 – no RAID
Boot Device	2 x 240GB M.2 BOSS in RAID1
Storage	2 X 64GB SD Module **(PowerTools)** 2 x 800GB SSD 2.5" **(Cache)** 6 x 1.8TB HDD 2.5" **(Capacity-Hybrid)** **Or** 6 x 1.92TB SSD 2.5" **(Capacity-AF)**
Network	Intel X710 QP 10Gb SFP(NDC)
iDRAC	iDRAC9 Enterprise
Power	2 x 2000W PSUs

3.4 Dell EMC VxRail Appliance platforms

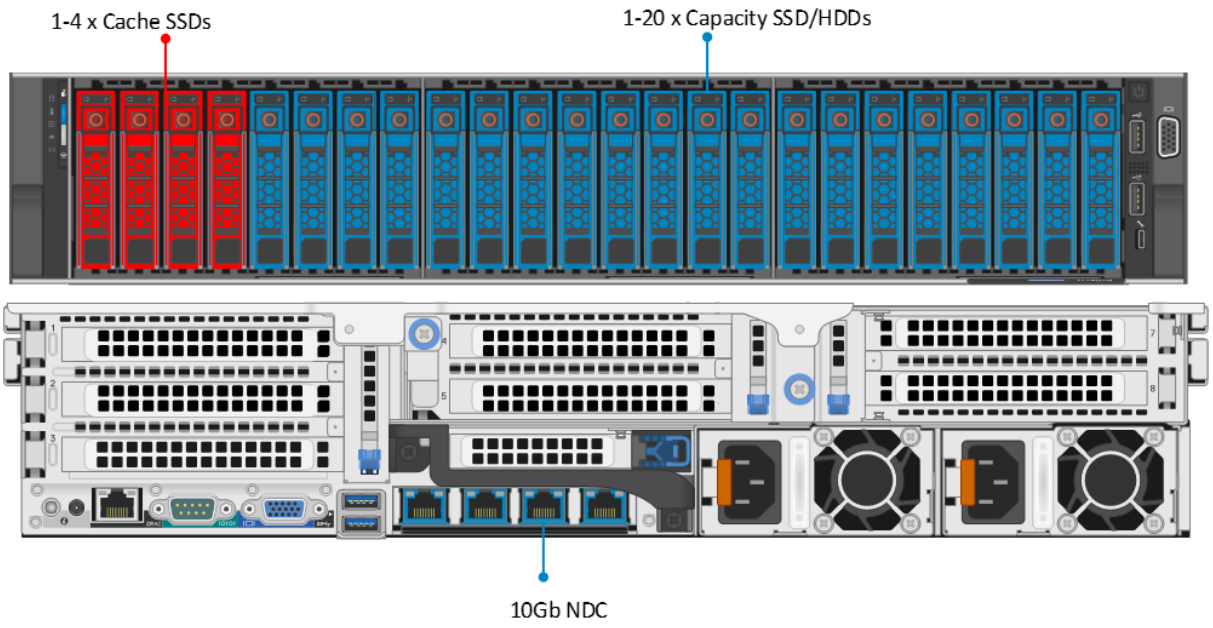
3.4.1 Dell EMC VxRail Appliance E Series (E560/E560F)

The E Series is the entry level platform, this comes with single or dual processors in a 1U configuration per node. These are aimed at basic workloads, remote offices, etc. The minimum amount of memory needed for the single CPU configuration is 96GB, and the maximum is 768GB. The minimum for a dual CPU configuration is 192GB and a maximum of 1.5TB. The M.2-based BOSS module is used for ESXi boot and minimum drive configuration is 1 x cache disk and 1 x capacity in a 1 disk group configuration. The maximum for this configuration is 2 x cache disks and 8 capacity in a two disk group configuration. Slot 8 and Slot 9 are to be used for cache disks only.



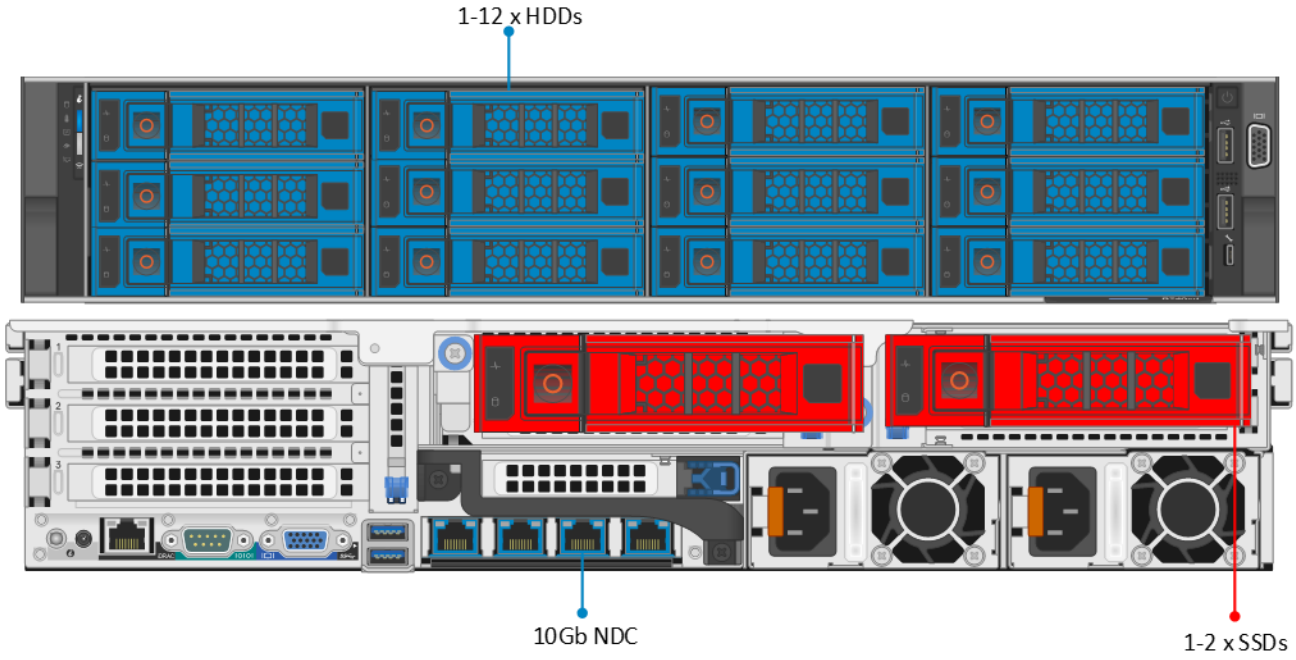
3.4.2 Dell EMC VxRail Appliance P Series (P570/P570F)

The P Series are performance optimized nodes aimed at high performance scenarios and heavy workloads. They come with a single or dual processor in a 2U configuration per node. The minimum amount of memory needed for the single CPU configuration is 96GB, and the maximum is 768GB. The minimum for a two socket CPU configuration is 192GB and the maximum is 1.5TB. The M.2-based BOSS module is used for ESXi boot and the minimum drive configuration is 1 x cache disk and 1 x capacity in a 1 diskgroup configuration. The maximum for this configuration is 4 x cache disks and 20 capacity in a four diskgroup configuration. The cache disks are located in Slots 20 to 23.



3.4.3 Dell EMC VxRail Appliance S Series Appliance (S570)

This is the storage dense platform designed for demanding applications such as virtualized Microsoft SharePoint, Microsoft Exchange, big data, and analytics. This comes with single or dual processors in a 2U configuration per node. The minimum amount of memory needed for the single CPU configuration is 96GB and the maximum is 768GB. The minimum for the dual CPU configuration is 192GB and a maximum of 1.5TB. The M.2-based BOSS module is used for ESXi boot and the minimum drive configuration is 1 x cache disk and 1 x capacity in a 1 disk group configuration. The maximum for this configuration is 2 x cache disks and 12 capacity drives in a two disk group configuration.



3.5 NVIDIA Tesla GPUs

Accelerate your most demanding enterprise data center workloads with NVIDIA® Tesla® GPU accelerators. Scientists can now crunch through petabytes of data up to 10x faster than with CPUs in applications ranging from energy exploration to deep learning. In addition, Tesla accelerators deliver the horsepower needed to run bigger simulations faster than ever before. For enterprises deploying VDI, Tesla accelerators are perfect for accelerating virtual desktops. GPUs can only be used in the V570/V570F appliance configuration.

3.5.1 NVIDIA Tesla M10

The NVIDIA Tesla M10 is a dual-slot 10.5 inch PCI Express Gen3 graphics card featuring four mid-range NVIDIA Maxwell™ GPUs and a total of 32GB GDDR5 memory per card (8GB per GPU). The Tesla M10 doubles the number of H.264 encoders over the NVIDIA Kepler™ GPUs and improves encoding quality, which enables richer colors, preserves more details after video encoding, and results in a high-quality user experience.

The NVIDIA Tesla M10 GPU accelerator works with NVIDIA GRID™ software to deliver the industry's highest user density for virtualized desktops and applications. It supports up to 64 desktops per GPU card (up to 128 desktops per server) and gives businesses the power to deliver great graphics experiences to all of their employees at an affordable cost.

Specs	Tesla M10
Number of GPUs/ card	4 x NVIDIA Maxwell™ GPUs
Total CUDA cores	2560 (640 per GPU)
GPU Clock	Idle: 405MHz / Base: 1033MHz
Total memory size	32GB GDDR5 (8GB per GPU)
Max power	225W
Form Factors	Dual slot (4.4" x 10.5")
Aux power	8-pin connector
PCIe	x16 (Gen3)
Cooling solution	Passive

3.5.2 NVIDIA Tesla M60

The NVIDIA Tesla M60 is a dual-slot 10.5 inch PCI Express Gen3 graphics card featuring two high-end NVIDIA Maxwell GPUs and a total of 16GB GDDR5 memory per card. This card utilizes NVIDIA GPU Boost technology which dynamically adjusts the GPU clock to achieve maximum performance. Additionally, the Tesla M60 doubles the number of H.264 encoders over the NVIDIA Kepler GPUs.

The NVIDIA Tesla M60 GPU accelerator works with NVIDIA GRID software to provide the industry's highest user performance for virtualized workstations, desktops, and applications. It allows enterprises to virtualize almost any application (including professional graphics applications) and deliver them to any device, anywhere.

Specs	Tesla M60
Number of GPUs/ card	2 x NVIDIA Maxwell GPUs
Total CUDA cores	4096 (2048 per GPU)
Base Clock	899 MHz (Max: 1178 MHz)
Total memory size	16GB GDDR5 (8GB per GPU)
Max power	300W
Form Factors	Dual slot (4.4" x 10.5")
Aux power	8-pin connector
PCIe	x16 (Gen3)
Cooling solution	Passive/ Active

3.6 Dell Wyse Thin Clients

The following Dell Wyse clients will deliver a superior Citrix XenDesktop user experience and are the recommended choices for this solution.

3.6.1 Wyse 3040 Thin Client (ThinOS, ThinLinux)

The Wyse 3040 is the industry's first entry-level Intel x86 quad-core thin client, powered by a quad-core Intel Atom 1.44GHz processor, delivering robust connectivity options with a choice of Wyse ThinOS or ThinLinux operating systems. The Wyse 3040 is Dell's lightest, smallest and most power-efficient thin client – it consumes 3.3 Watts in idle state – and offers superb performance and manageability for task and basic productivity users. Despite its small size, the 3040 includes all typical interfaces such as four USB ports including USB 3.1, two DisplayPort interfaces and wired and wireless options. It is highly manageable as it can be monitored, maintained, and serviced remotely via Wyse Device Manager (WDM) or Wyse Management Suite. For more information, please visit: Link

3.6.2 Wyse 5010 Thin Client (ThinOS)

Designed for knowledge workers and power users, the Wyse 5010 is a high performance thin client based on Wyse ThinOS, the virus-resistant firmware base designed for optimal thin client security, performance, and ease-of-use. Highly secure, compact and powerful, it combines a dual-core AMD 1.4 GHz CPU with a revolutionary unified graphics engine for an outstanding user experience. It addresses the performance challenges of processing-intensive applications like computer-aided design, multimedia, HD video and 3D modelling. Scalable on premise or cloud-based management provides simple deployment, patching, and updates. Take a unit from box to productivity in minutes with auto configuration. Delivering outstanding processing speed and power, security and display performance, the Wyse 5010 offers a unique combination of performance, efficiency, and affordability. For more information, please visit: Link

3.6.3 Wyse 5060 Thin Client (ThinOS, ThinLinux, WES7P, WIE10)

The Wyse 5060 offers high performance and reliability, featuring all the security and management benefits of Dell thin clients. It come with flexible OS options: ThinOS, ThinLinux, Windows Embedded Standard 7P (WES7P) or Windows 10 IoT Enterprise (WIE10). Designed for knowledge workers demanding powerful virtual desktop performance, and support for unified communications solutions like Skype for Business, the Wyse 5060 thin client delivers the flexibility, efficiency and security organizations require for their cloud environments. It is powered by a quad-core AMD 2.4GHz processor, supports dual 4K (3840x2160) monitors and provides multiple connectivity options with six USB ports, two of which are USB 3.0 for high-speed peripherals, as well as two DisplayPort connectors, wired networking or wireless 802.11 a/b/g/n/ac. The Wyse 5060 can be monitored, maintained, and serviced remotely via Wyse Device Manager (WDM), cloud-based Wyse Management Suite or Microsoft SCCM (5060 with Windows versions). For more information, please visit: Link

3.6.4 Wyse 7020 PCoIP Zero Client (WES 7/7P, WIE10, ThinLinux)

The versatile Dell Wyse 7020 thin client is a powerful endpoint platform for virtual desktop environments. It is available with Windows Embedded Standard 7/7P (WES), Windows 10 IoT Enterprise (WIE10), Wyse ThinLinux operating systems and it supports a broad range of fast, flexible connectivity options so that users can connect their favorite peripherals while working with processing-intensive, graphics-rich applications. This 64-bit thin client delivers a great user experience and support for local applications while ensuring security.

Designed to provide a superior user experience, ThinLinux features broad broker support including Citrix Receiver, VMware Horizon and Amazon Workspace, and support for unified communication platforms including Skype for Business, Lync 2013 and Lync 2010. For additional security, ThinLinux also supports single sign-on and VPN. With a powerful quad core AMD G Series APU in a compact chassis with dual-HD monitor support, the Wyse 7020 thin client delivers stunning performance and display capabilities across 2D, 3D and HD video applications. Its silent diskless and fan less design helps reduce power usage to just a fraction (it only consumes about 15 watts) of that used in traditional desktops. Wyse Device Manager (WDM) helps lower the total cost of ownership for large deployments and offers remote enterprise-wide management that scales from just a few to tens of thousands of cloud clients. For more information, please visit: Link

3.6.5 Wyse 7040 Thin Client (WES7P, WIE10)

The Wyse 7040 is a high-powered, ultra-secure thin client running Windows Embedded Standard 7P (WES7P) or Windows 10 IoT Enterprise (WIE10) operating systems. Equipped with an Intel i5/i7 processors, it delivers extremely high graphical display performance (up to three displays via display-port daisy-chaining, with 4K resolution available on a single monitor) for seamless access to the most demanding applications. The Wyse 7040 is compatible with both data center hosted and client-side virtual desktop environments and is compliant with all relevant U.S. Federal security certifications including OPAL compliant hard-drive options, VPAT/Section 508, NIST BIOS, Energy-Star and EPEAT. Wyse enhanced WES7P OS provides additional security features such as BitLocker. The Wyse 7040 offers a high level of connectivity including dual NIC, 6 x USB3.0 ports and an optional second network port, with either copper or fiber SFP interface. Wyse 7040 devices are highly manageable through Intel vPRO, Wyse Device Manager (WDM), Microsoft System Center Configuration Manager (SCCM) and Dell Command Configure (DCC). For more information, please visit: Link.

3.6.6 Latitude 3480 and 5280 Mobile Thin Clients (Win 10 IoT)

Designed to securely deliver virtual desktops and applications to mobile users who want to connect a broad range of peripherals, the Latitude 3480 and 5280 mobile thin clients run **Windows 10 IoT Enterprise**. They support a wide variety of connection brokers including Citrix XenDesktop/XenApp, Microsoft RDS and VMware Horizon right out of the box, and are an ideal alternative to much less secure Chromebooks. The Latitude 3480 features an Intel dual core processor with integrated graphics for a rich multimedia experience, and delivers great value with a 14'' Full-HD display and robust connectivity with plenty of ports. The Latitude 5280 delivers excellent performance with 12.5-inch, Full HD display. It offers the ability to support a 4K monitor via an optional docking station, and it supports a broad mix of peripheral attachments and network connections. They are is easily manageable through Wyse Device Manager (WDM), Wyse Management Suite and Microsoft's System Center Configuration Manager (SCCM). For enhanced security, optional advanced threat protection in the form of Dell Threat Defense offers proactive malware protection. For more information, please visit the following pages for: Latitude 3480 and Latitude 5280.

4 Software Components

4.1 VMware vSphere 6.5

The vSphere hypervisor also known as ESXi is a bare-metal hypervisor that installs directly on top of your physical server and partitions it into multiple virtual machines. Each virtual machine shares the same physical resources as the other virtual machines and they can all run at the same time. Unlike other hypervisors, all management functionality of vSphere is done through remote management tools. There is no underlying operating system, reducing the install footprint to less than 150MB.

VMware vSphere includes three major layers: Virtualization, Management and Interface. The Virtualization layer includes infrastructure and application services. The Management layer is central for configuring, provisioning and managing virtualized environments. The Interface layer includes the vSphere web client.

Throughout the Dell Wyse Datacenter solution, all VMware and Microsoft best practices and prerequisites for core services are adhered to (NTP, DNS, Active Directory, etc.). The vCenter used in the solution is a vCenter Server Appliance (VCSA) residing on a host in the management Tier.

VMware vSphere® 6.x is the next-generation infrastructure for next-generation applications. It provides a powerful, flexible, and secure foundation for business agility that accelerates the digital transformation to cloud computing and promotes success in the digital economy.

Improved Appliance Management

vCenter Server Appliance also exclusively provides improved appliance management capabilities. The vCenter Server Appliance Management interface continues its evolution and exposes additional configuration data. In addition to CPU and memory statistics, it now shows network and database statistics, disk space usage and health data. This reduces reliance on a command-line interface for simple monitoring and operational tasks.

VMware vCenter High Availability

vCenter Server has a new native high availability solution that is available exclusively for vCenter Server Appliance. This solution consists of active, passive, and witness nodes that are cloned from the existing vCenter Server instance. The VMware vCenter® High Availability (vCenter HA) cluster can be enabled, disabled, or destroyed at any time. There is also a maintenance mode that prevents planned maintenance from causing an unwanted failover. vCenter HA uses two types of replication between the active and passive nodes: Native PostgreSQL synchronous replication is used for the vCenter Server database; a separate asynchronous file system replication mechanism is used for key data outside of the database.

Failover can occur when an entire node is lost—host failure, for example—or when certain key services fail. For the initial release of vCenter HA, a recovery time objective (RTO) of about 5 minutes is expected, but this can vary slightly depending on the load, size, and capabilities of the underlying hardware.

Backup and Restore

New with the latest vCenter Server is native backup and restore for the vCenter Server Appliance. This new, out-of-the-box functionality enables users to back up vCenter Server and Platform Services Controller appliances directly from the VAMI or API. The backup consists of a set of files that is streamed to a storage device of the user's choosing using SCP, HTTP(S), or FTP(S) protocols. This backup fully supports VCSA instances with both embedded and external Platform Services Controller instances.

vSphere HA Support for NVIDIA GRID vGPU Configured VMs

vSphere HA now protects VMs with the NVIDIA GRID vGPU shared pass-through device. In the event of a failure, vSphere HA attempts to restart the VMs on another host that has an identical NVIDIA GRID vGPU profile. If there is no available healthy host that meets this criterion, the VM fails to power on. For more information on HA Support for NVIDIA GRID vGPU please visit the Blog article located here.

For more information on VMware vSphere and what's new in this release, visit link.

4.2 VMware vSAN

This release of VMware vSAN delivers following important new features and enhancements:

Deduplication and compression: VMware vSAN now supports deduplication and compression to eliminate duplicate data. This technique reduces the total storage space required to meet your needs. When you enable deduplication and compression on a VMware vSAN cluster, redundant copies of data in a particular disk group are reduced to single copy. Deduplication and compression are available as a cluster-wide setting only available as a feature on all-flash clusters.

Enabling deduplication and compression can reduce the amount of storage consumed by as much as 7x. Actual reduction numbers will vary as this depends primarily on the types of data present, number of duplicate blocks, how much these data types can be compressed, and distribution of these unique blocks.

RAID 5 and RAID 6 erasure coding: VMware vSAN now supports both RAID 5 and RAID 6 erasure coding to reduce the storage space required to protect your data. RAID 5 and RAID 6 are available as a policy attribute for VMs in all-flash clusters.

Quality of Service: With the Quality of Service addition to VMware vSAN IOPS limits are now available. Quality of service for VMware vSAN is a Storage Policy Based Management (SPBM) rule. Because quality of service is applied to VMware vSAN objects through a Storage Policy, it can be applied to individual components or the entire virtual machine without interrupting the operation of the virtual machine.

The term "noisy neighbor" is often used to describe when a workload monopolizes available I/O or other resources, which negatively affect other workloads on the same platform.

For more information on what's new in VMware vSAN, please visit this link.

4.2.1 vSAN best practices

When determining the amount of capacity required for a VMware vSAN Design we need to pay close attention to the number of FailuresToTolerate (FTT) policy setting. The default storage policies that are deployed have FTT=1 and that is the recommended default FTT policy setting. When we have FTT=1 set in our policy it will mirror each VMDK in the virtual machine configuration, so if you have two VMDKs that are 40Gb & 20Gb respectively the amount of virtual machine space needed for that virtual machine is 120Gb (40GB x 2 + 20GB x 2).

We also need to factor in how much free capacity or "Slack Space" needs to be preserved when designing the capacity requirement for the VMware vSAN Cluster. The recommendation by VMware is that this should be 30%. The reasoning for this slack space size that the VMware vSAN will begin automatically rebalancing when a disk reaches the 80% full threshold and the additional 10% has been added as a buffer. This is not a hard limit or set via a security policy so the customer can actually use this space but should be made aware of the performance implications of going over the 80% full threshold. More information can be found on the design and sizing of VMware vSAN6.2 Cluster here

4.2.2 All-Flash versus Hybrid

The most signification new features in this latest version of VMware vSAN are Deduplication & Compression and erasure coding. These features are only supported in an All-Flash VMware vSAN configuration. The hesitance of a customer going the all flash route is cost but if you factor in the capacity savings achieved by these new features it bridges the gap between the Hybrid & All Flash configurations.

The scenario below is using a VM which consumes 50 GB of space. The hybrid configuration has a default FTT value of 1 and Failure Tolerance Method (FTM) of RAID-1 which has 2x overhead and with FTT=2 that has 3x overhead. The FTM of RAID5/6 is only available with the all-flash configuration and with FTT=1 the overhead is 1.33x, for FTT=2 is 1.5x.

Comparing both FTT=1 scenarios below for both the hybrid and all-flash we can see the capacity savings of over 33GBs per VM so if we had 200VMs per Host that's a capacity saving of over 660GB of usable VM space per Host.

VM Size	FTM	FTT	Overhead	Configuration	Capacity Required	Hosts Required
50GB	RAID-1	1	2x	Hybrid	100GB	3
50GB	RAID-5	1	1.33x	All-Flash	66.5GB	4
50GB	RAID-1	2	3x	All-Flash	150GB	4
50GB	RAID-6	2	1.5x	All-Flash	75GB	6

Prior to VMware vSAN 6.2, RAID-1 (Mirroring) was used as the failure tolerance method. VMware vSAN 6.2 adds RAID-5/6 (Erasure Coding) to all-flash configurations. While RAID 1(Mirroring) may be favored where performance is the most important factor it is costly with regards to the amount of storage needed.

RAID-5/6 (Erasure Coding) data layout can be configured to help ensure the same levels of availability, while consuming less capacity than RAID-1 (Mirroring). Use of erasure coding reduces capacity consumption by as much as 50% versus mirroring at the same fault tolerance level. This method of fault tolerance does require additional write overhead in comparison to mirroring as a result of data placement and parity.

Deduplication and Compression are two new features that are only available with the all-flash configuration. These features cannot be enabled separately and are implemented at the cluster level. When enabled, VMware vSAN will aim to deduplicate each block and compress the results before destaging the block to the capacity layer. Deduplication and compression work at a disk group level and only objects that are deployed on the same disk group can contribute towards space savings, if components from identical VMs are deployed to different disk groups there will not be any deduplication of identical blocks of data.

The VMware vSAN Read/Write process for both hybrid and all-flash are not the same.

VMware vSAN Hybrid Read: For an object placed on a VMware vSAN datastore, when using RAID-1 configuration it is possible that there are multiple replicas when the number of failure to tolerate are set to greater than 0. Reads may now be spread across the replicas, different reads may be sent to different replicas according to the logical block address and this is to ensure that VMware vSAN does not consume more read cache than is necessary, this avoids caching the data in multiple locations.

VMware vSAN All-Flash Read: Since there is no read cache in an All Flash configuration the process is much different to the Hybrid read operation. The write buffer is first checked to see if the block is present when a read is issued on an all-flash VMware vSAN. This is also the case on hybrid but the difference being with hybrid is that if the block is located in the write buffer it will not be fetched from here. If the requested block is not in the write buffer it will be fetched from the capacity tier but since the capacity tier is also SSD the latency overhead in the first checking the cache and then the capacity tier is minimal. This is main reason why there isn't a read cache with all-flash, the cache tier is a dedicated write buffer which in turns frees up the cache tier for more writes boosting overall IOPS performance.

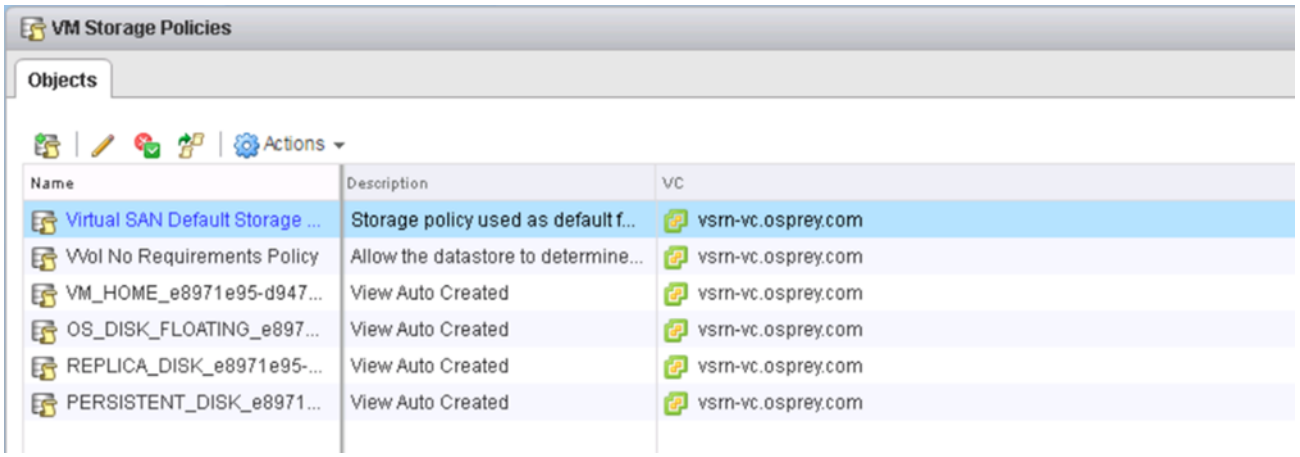
VMware vSAN Hybrid Write: When a VM is deployed on a hybrid cluster the components of the VM are spread across multiple hosts so when an application within that VM issues a write operation, the owner of the object clones the write operation. This means that the write is sent to the write cache on Host 1 and Host 2 in parallel.

VMware vSAN All-Flash Write: The write process on all-flash is similar to the write process on hybrid, the major difference between both is that with all-flash 100% of the cache tier is assigned to the write buffer whereas with hybrid only 30% is assigned to the write buffer, and the other 70% is assigned to the read cache.

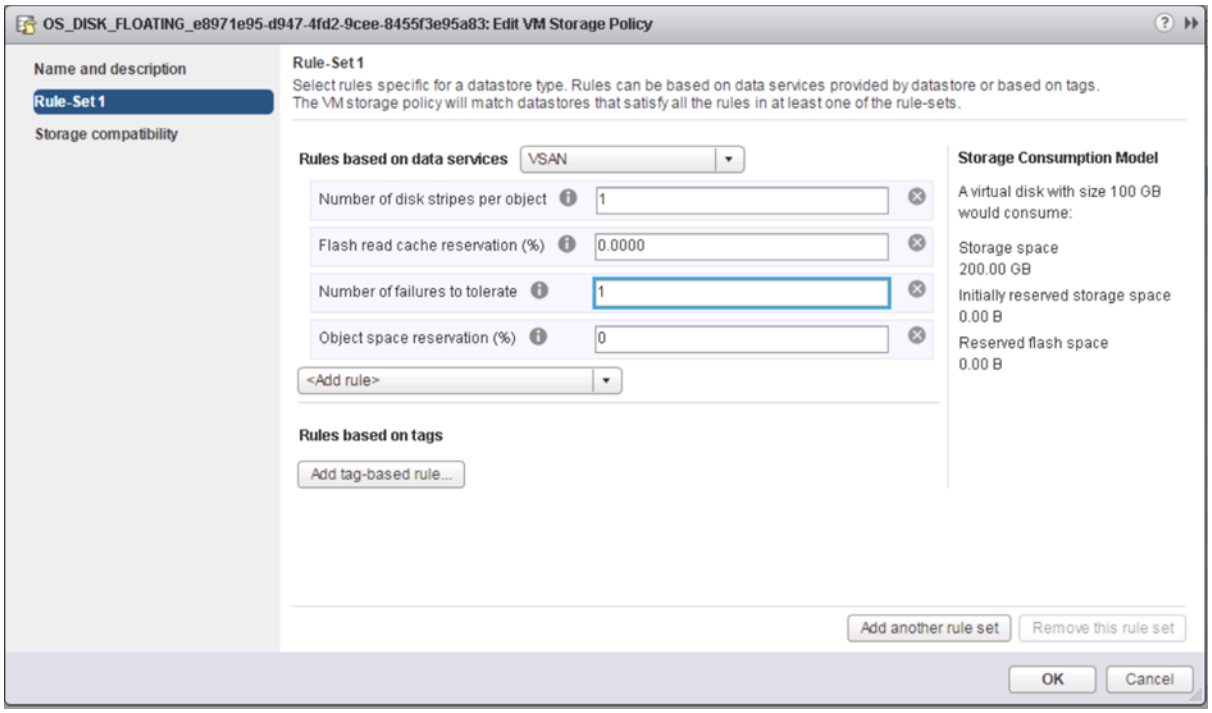
4.2.3 VM storage policies for VMware vSAN

Storage policy plays a major role for VMware vSAN strategy and performances. After data store creation you can create VM storage policies to meet VM availability, sizing and performance requirements. The policies are applied down to the VMware vSAN layer when a VM is created. The VM virtual disk is distributed across the VMware vSAN datastore per policy definition to meet the requirements.

When this is selected a set of storage policies are deployed and visible from with the vSphere Web Console (monitoring/VM Storage Policies).



Each policy can be edited but it is recommended to refer to design and sizing guide for VMware vSAN 6.2 located here before making any change to the policy.



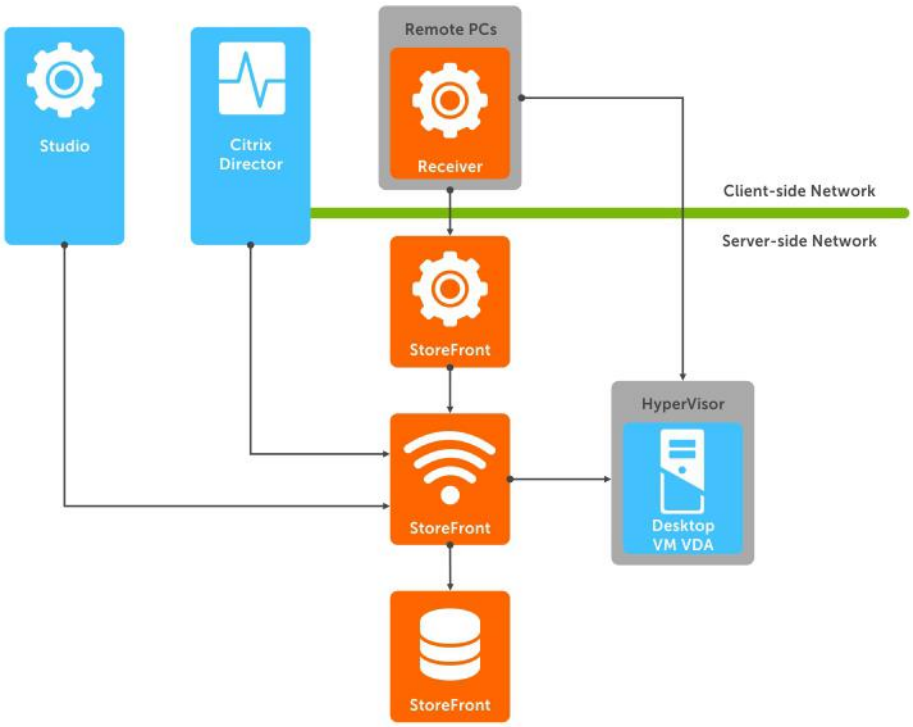
4.3 Citrix

4.3.1 Citrix XenDesktop

The solution is based on Citrix XenDesktop which provides a complete end-to-end solution delivering Microsoft Windows virtual desktops or server-based hosted shared sessions to users on a wide variety of endpoint devices. Virtual desktops are dynamically assembled on demand, providing users with pristine, yet personalized, desktops each time they log on.

Citrix XenDesktop provides a complete virtual desktop delivery system by integrating several distributed components with advanced configuration tools that simplify the creation and real-time management of the virtual desktop infrastructure. Citrix announced support for VMware vSAN with Citrix XenDesktop with the recently released 7.1x version.

Note: It is important to apply all necessary hotfixes to ensure smooth operation between XD 7.1x and VMware vSAN 6.2, please go to https://www.citrix.com/downloads/xendesktop/ to check what current hotfixes need to be applied.



The core XenDesktop components include:

Studio - Studio is the management console that enables you to configure and manage your deployment, eliminating the need for separate management consoles for managing delivery of applications and desktops. Studio provides various wizards to guide you through the process of setting up your environment, creating your workloads to host applications and desktops, and assigning applications and desktops to users.

Delivery Controller (DC) - Installed on servers in the data center, the controller authenticates users, manages the assembly of users' virtual desktop environments, and brokers connections between users and their virtual desktops. The Controller also manages the state of desktops, starting and stopping them based on demand and administrative configuration.

Database - At least one Microsoft SQL Server database is required for every XenApp or XenDesktop Site to store configuration and session information. The Delivery Controller must have a persistent connection to the database as it stores data collected and managed by the Controller services.

Director - Director is a web-based tool that enables IT support teams to monitor an environment, troubleshoot issues before they become system-critical, and perform support tasks for end users. You can also view and interact with a user's sessions using Microsoft Remote Assistance. Starting in version 7.12, Director now includes detailed descriptions for connection and machine failures, one month historical data (Enterprise edition), custom reporting, and notifications via SNMP traps.

Receiver - Installed on user devices, Citrix Receiver provides users with quick, secure, self-service access to documents, applications, and desktops from any of the user's devices including smartphones, tablets, and PCs. Receiver provides on-demand access to Windows, Web, and Software as a Service (SaaS) applications. For devices that cannot install the Receiver software, Citrix Receiver for HTML5 provides connectivity through a HTML5-compatible web browser.

StoreFront - StoreFront authenticates users to sites hosting resources and manages stores of desktops and applications that user's access. StoreFront version 3.8 (released with XenDesktop 7.12) and above includes ability to create and use multiple IIS websites each having its own domain name.

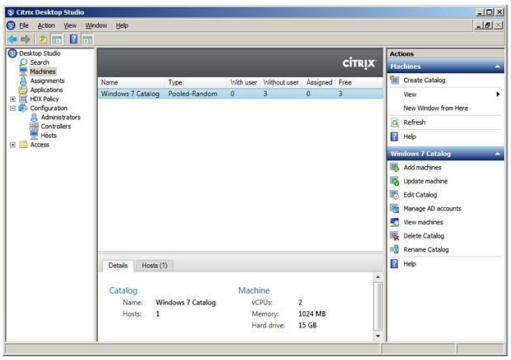
License Server - The Citrix License Server is an essential component at any Citrix-based solution. Every Citrix product environment must have at least one shared or dedicated license server. License servers are computers that are either partly or completely dedicated to storing and managing licenses. Citrix products request licenses from a license server when users attempt to connect.

Machine Creation Services (MCS) - A collection of services that work together to create virtual servers and desktops from a master image on demand; optimizing storage utilization and providing a pristine virtual machine to users every time they log on. Machine Creation Services is fully integrated and administrated in Citrix Studio.

Provisioning Services (PVS) - The Provisioning Services infrastructure is based on software-streaming technology. This technology allows computers to be provisioned and re-provisioned in real-time from a single shared-disk image.

Virtual Delivery Agent (VDA) - The Virtual Desktop Agent is a transparent plugin that is installed on every virtual desktop or XenApp host (RDSH) and enables the direct connection between the virtual desktop and users' endpoint devices. Windows and Linux VDAs are available.

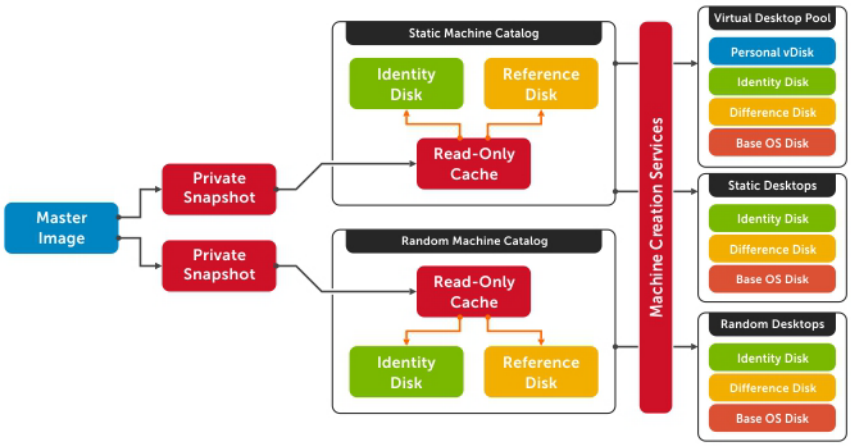
4.3.2 Machine Creation Services (MCS)



Citrix Machine Creation Services is the native provisioning mechanism within Citrix XenDesktop for virtual desktop image creation and management. Machine Creation Services uses the hypervisor APIs to create, start, stop, and delete virtual desktop images. Desktop images are organized in a Machine Catalog and within that catalog there are a number of options available to create and deploy virtual desktops:

- **Random**: Virtual desktops are assigned randomly as users connect. When they logoff, the desktop is reset to its original state and made free for another user to login and use. Any changes made by the user are discarded at log off.
- **Static**: Virtual desktops are assigned to the same user every time with three options for how to handle changes made to the desktop: Store on local vDisk, Personal vDisk, or discarded on user log off.

All the desktops in a random or static catalog are based off a master desktop template which is selected during the catalog creation process. MCS then takes snapshots of the master template and layers two additional virtual disks on top: an Identity vDisk and a Difference vDisk. The Identity vDisk includes all the specific desktop identity information such as host names and passwords. The Difference vDisk is where all the writes and changes to the desktop are stored. These Identity and Difference vDisks for each desktop are stored on the same data store as their related clone.



While traditionally used for small to medium sized XenDesktop deployments, MCS can bring along with it some substantial Tier 1 storage cost savings because of the snapshot/identity/difference disk methodology. The Tier 1 disk space requirements of the identity and difference disks when layered on top of a master image snapshot, is far less than that of a dedicated desktop architecture.

4.3.3 Provisioning Services (PVS)

PVS is an alternative method of image provisioning which uses streaming to share a single base vDisk image instead of copying images to VMs. PVS are used to deliver shared vDisk images to physical or virtual machines. Another potential use is the serial provisioning of XenApp to enable scale-out hosted shared desktop infrastructure. Provisioning Services enables real-time streamed provisioning and re-provisioning which enable administrators to completely eliminate the need to manage and patch individual systems.

Desktop images are organized in a Machine Catalog and within that catalog there are a number of options available to create and deploy virtual or physical desktops:

- **Random**: Virtual or physical desktops are assigned randomly as users connect. When they logoff, the desktop is reset to its original state and made free for another user to login and use. Any changes made by the user are discarded at log off.
- **Static**: Virtual desktops are assigned to the same user every time with user changes stored on a separate Personal vDisk.

Using Provisioning Services, vDisk images are configured in Standard Image mode, read-only, or Private Image mode, read/write. A vDisk in Standard Image mode allows multiple desktops to boot from it simultaneously greatly reducing the number of images that must be maintained and the amount of storage that is otherwise required (non-persistent). Private Image mode vDisks are equivalent to dedicated hard disks and can only be used by one target device at a time (persistent). The Provisioning Server runs on a virtual instance of Windows Server 2012 R2 or Windows 2016 on the Management Server(s).

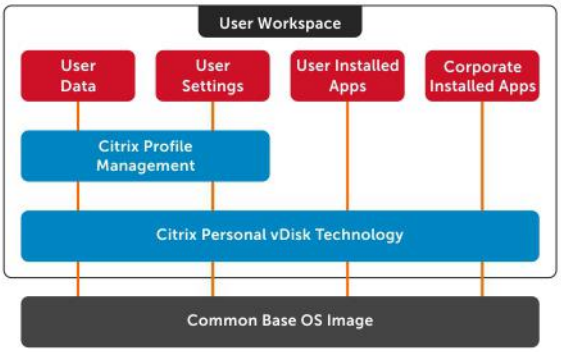
4.3.3.1 PVS Write Cache

Citrix Provisioning Services delivery of standard images relies on write-caches to store any writes made by the target OS. The most common write-cache implementation places write-cache on the target machine's storage. Independent of the physical or virtual nature of the target machine, this storage has to be allocated and formatted to be usable.

While there are 4 possible locations for storage of the write cache in PVS, the Dell Wyse Datacenter solution recommends placement of the PVS write cache in the target compute host's RAM with overflow enabled. We recommend using a cache size of 512MB for virtual desktops and 21GB for XenApp VMs delivered via PVS.

4.3.4 Personal vDisk

Citrix Personal vDisk is an enterprise workspace virtualization solution that is built into Citrix XenDesktop. Personal vDisk provides the user customization and personalization benefits of a persistent desktop image with the storage savings and performance of a single/shared image.



Used in conjunction with a static desktop experience, Citrix Personal vDisk allows each user to receive personal storage in the form of a layered vDisk (3GB minimum). This personal vDisk enables users to personalize and persist their desktop environment while providing storage for any user or departmental apps.

Personal vDisk provides the following benefits to XenDesktop:

- Persistent personalization of user profiles, settings and data
- Enables deployment and management of user installed and entitlement based applications
- Fully compatible with Microsoft SCCM and App-V
- 100% persistence with VDI pooled Storage management
- Near Zero management overhead

4.3.5 HDX 3D Pro

XenDesktop with HDX 3D Pro is a desktop and app virtualization solution that supports high-end designers and engineers of 3D professional graphics applications and provides cost-effective support to viewers and editors of 3D data. With XenDesktop, you can deliver a persistent user experience and leverage other virtualization benefits such as single-image management and improved data security.

Use HDX 3D Pro technologies with:

- Computer-aided design, manufacturing, and engineering (CAD/CAM/CAE) applications
- Geographical information system (GIS) software
- Picture Archiving Communication System (PACS) workstations for medical imaging
- Latest OpenGL, DirectX, CUDA and CL versions supported
- Latest NVIDIA Grid cards
- Shared or dedicated GPUs or a mix of both on desktop or server OS VMs

HDX 3D Pro provides the best user experience over any bandwidth using Framehawk integration:

- On wide area network (WAN) connections: Deliver an interactive user experience over WAN connections with bandwidths as low as 1.5 Mbps.
- On local area network (LAN) connections: Deliver a user experience equivalent to that of a local desktop on LAN connections.

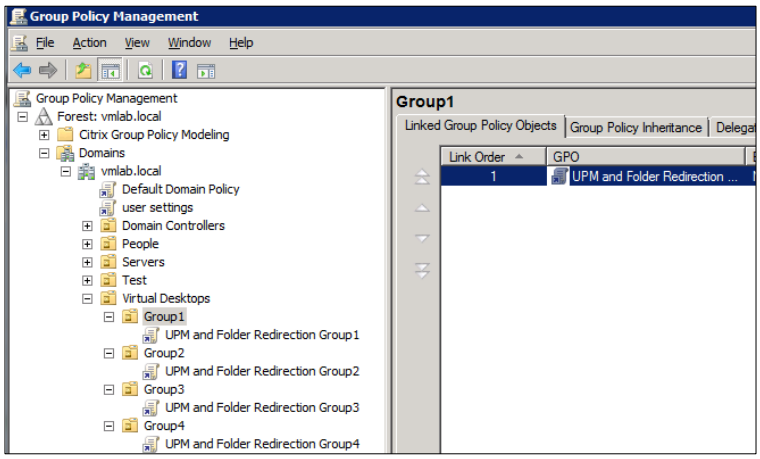
Framehawk is a display remoting technology implemented as an ICA virtual channel that optimizes delivery of virtual desktops and applications to users on broadband wireless connections where high packet loss or congestion occurs.

4.3.6 Citrix Profile Manager

Citrix Profile Management is a component of the XenDesktop suite which is used to manage user profiles and minimize many of the issues associated with traditional Windows roaming profiles in an environment where users may have their user profile open on multiple devices at the same time. The profile management toolset has two components: the profile management agent, installed on any device where the user profiles is managed, and a Group Policy Administrative Template, which is imported to a group policy.

In order to further optimize, the profile management folders within the user profile is redirected the users' home drive. The folder redirection is managed via group policy objects within Active Directory. The following folders are redirected:

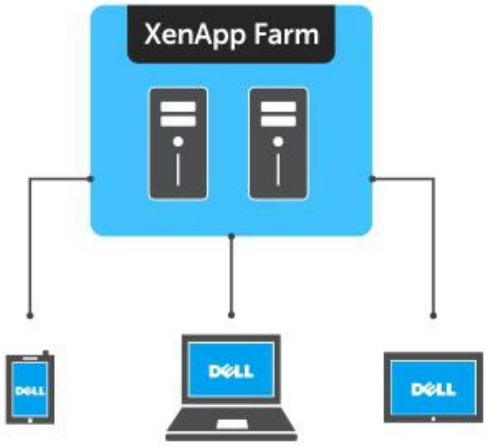
- Contacts
- Downloads
- Favorites
- Links
- My Documents
- Searches
- Start Menu
- Windows
- My Music
- My Pictures
- My Videos
- Desktop



4.3.7 Citrix XenApp

Citrix XenApp 7.8 includes enhancements in the areas of faster access to virtual apps with higher connection resiliency, improved graphics rendering, and new app-usage reporting and monitoring tools.

Citrix XenApp delivers Windows apps as secure mobile services. With XenApp, IT can mobilize the business - increasing user productivity, while reducing costs by centralizing control and security of intellectual property. XenApp delivers high-performance apps to any PC, Mac, laptop, tablet or smartphone that enable the delivery of a native experience that is optimized for the type of device, as well as the network. XenApp is built on a 3rd generation FlexCast Management Architecture (FMA) and is the only hybrid cloud-ready platform that separates the management plane from the workload to enable IT to securely deliver published apps on-premises, and manage workers and mobile workspaces either on-premises or in the cloud.



Benefits of hosted desktop sessions and applications:

- Management of applications (single instance)
- Management of simple desktop images (no applications installed)
- PVS to stream XenApp servers as well as user desktops
- Scalability of XenDesktop compute hosts: CPU and IOPS reduction via application offload
- Shared storage scalability: less IOPS = more room to grow

Citrix XenDesktop with XenApp integration can effectively deliver a desktop/application hybrid solution as well. Specifically where a single or small number of shared VDI desktop images are deployed via XenDesktop, each with common shared applications installed within the golden image. A user-specific application set is then deployed and made accessible via the hosted application compute infrastructure, accessible from within the virtual desktop.

User Environment	XenDesktop	XenApp
User-Specific Applications		✓
Profile and User Data	✓	✓
Shared Applications	✓	
Shared Virtual Desktop Image	✓	

Alternatively, XenApp provides a platform for delivering Windows server-based sessions to users who may not need a full desktop VM. Hosted desktops increase infrastructure resource utilization while reducing complexity as all applications and sessions are centrally managed.

User Environment	XenDesktop	XenApp
User-Specific Applications		✓
Profile and User Data		✓
Dedicated Virtual Desktop Image		✓

4.3.7.1 XenApp Integration into Dell Wyse Datacenter Architecture

The XenApp servers can exist as physical or virtualized instances of Windows Server 2012 R2. A minimum of one, up to a maximum of 10 virtual servers are installed per physical compute host. Since XenApp instances are easily added to an existing XenDesktop stack, the only additional components required are:

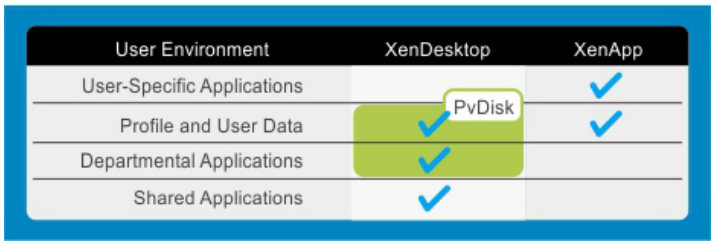
- One or more Windows Server OS instances running the Citrix VDA added to the XenDesktop site

The total number of required virtual XenApp servers is dependent on application type, quantity and user load. Deploying XenApp virtually and in a multi-server farm configuration increases overall farm performance, application load balancing as well as farm redundancy and resiliency.

4.3.7.2 XenDesktop with XenApp and Personal vDisk Integration

In a XenDesktop implementation that leverages hosted applications, these execute from a centralized Windows Server and are then accessed via the Citrix Receiver. There are some instances, however, where certain departmental or custom applications cannot run using XenApp. At the same time for organizational policy or certain storage considerations, delivering these applications as a part of a base image is not possible either. In this case, Citrix Personal vDisk technology is the appropriate solution.

With Citrix Personal vDisk, each user of that single shared virtual desktop image also receives a personal layered vDisk, which enables the user to personalize their desktop and receive native application execution within a Windows client OS and not from a server. When leveraging the integration of XenApp within XenDesktop, all profile and user data is seamlessly accessed within both environments.



4.3.7.3 PVS Integration with XenApp

One of the many benefits of PVS is the ability to quickly scale the XenApp instances within a farm. Bandwidth is a key consideration and PVS bandwidth utilization is mostly a function of the number of target devices and the portion of the image(s) they utilize. Network impact considerations include:

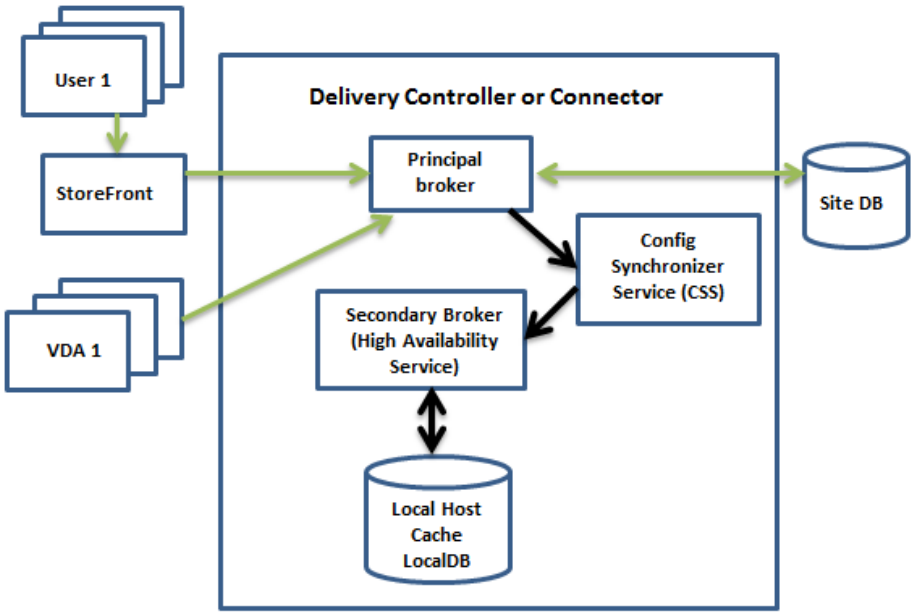
- PVS streaming is delivered via UDP, yet the application has built-in mechanisms to provide flow control, and retransmission as necessary.
- Data is streamed to each target device only as requested by the OS and applications running on the target device. In most cases, less than 20% of any application is ever transferred.
- PVS relies on a cast of supporting infrastructure services. DNS and DHCP need to be provided on dedicated service infrastructure servers, while TFTP and PXE Boot are functions that may be hosted on PVS servers or elsewhere.

4.3.8 Local Host Cache

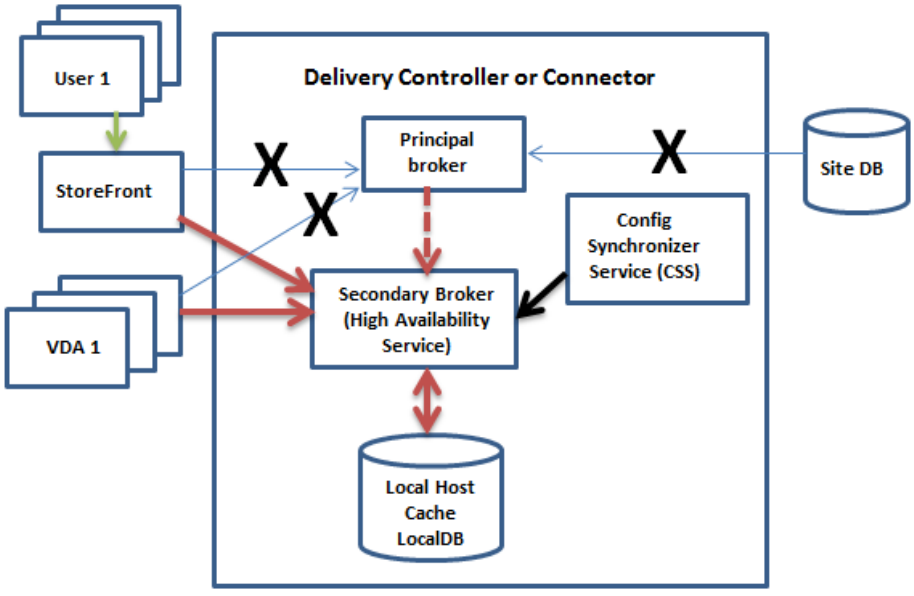
In XenApp and XenDesktop version 7.12 and above, the Local Host Cache (LHC) feature allows connection brokering operations to continue when connectivity to the Site database has been interrupted. This includes both failures between the Delivery Controller and Site database in on-premises deployments and when the WAN link between the Site and Citrix control plane fails in a Citrix Cloud environment. LHC replaces the connection leasing feature as the recommended XenApp and XenDesktop high availability solution. During

an outage, LHC will support new users and existing users launching new resources, as well as users accessing pooled resources (shared desktops). Earlier versions of XenApp had a feature named Local Host Cache but this is an entirely different implementation that is more robust and immune to corruption.

The following diagram shows the communication paths during normal operations. The principal broker on a delivery controller accepts requests and communicates with the Site database to connect users. A check is made every two minutes to determine if changes have been made to the principal broker's configuration and if so, the information is synchronized with the secondary broker. All configuration data is copied to ensure the LocalDB database matches the site database.



The following diagram illustrates changes in communication when the principal broker is unable to connect to the Site database.



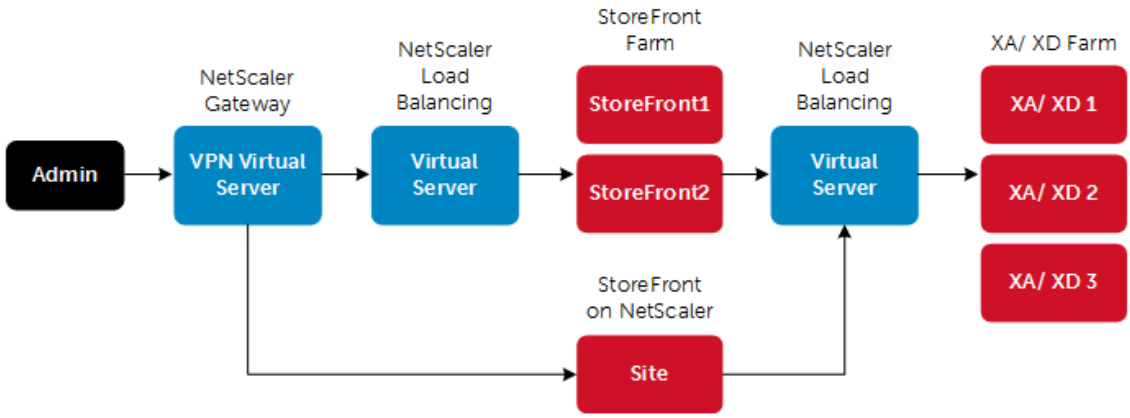
The principal broker stops listening for requests and instructs the secondary broker to begin listening and processing requests. When a VDA communicates with the secondary broker, a re-registration process is triggered during which current session information is delivered. During this time, the principal broker continually monitors the connection to the Site database. Once restored, the principal broker resumes brokering operations and instructs the secondary broker to stop listening for connection information.

4.3.9 Citrix NetScaler

Citrix NetScaler is an all-in-one web application delivery controller that makes applications run better, reduces web application ownership costs, optimizes the user experience, and makes sure that applications are always available by using:

- Proven application acceleration such as compression and caching
- High application availability through advanced L4-7 load balancer
- Application security with an integrated application firewall
- Server offloading to significantly reduce costs and consolidate servers

A NetScaler appliance resides between the clients and the servers, so that client requests and server responses pass through it. In a typical installation, virtual servers (vservers) configured on the NetScaler provide connection points that clients use to access the applications behind the NetScaler. In this case, the NetScaler owns public IP addresses that are associated with its vservers, while the real servers are isolated in a private network. It is also possible to operate the NetScaler in a transparent mode as an L2 bridge or L3 router, or even to combine aspects of these and other modes. NetScaler can also be used to host the StoreFront function eliminating complexity from the environment.



Global Server Load Balancing

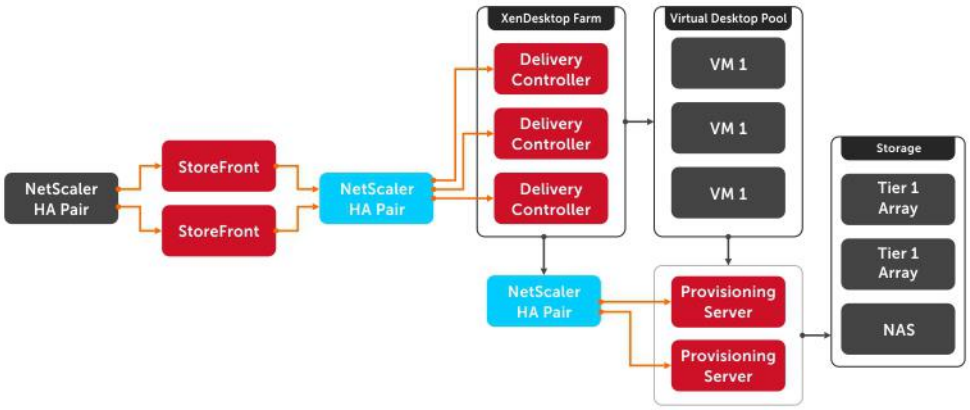
GSLB is an industry standard function. It is in widespread use to provide automatic distribution of user requests to an instance of an application hosted in the appropriate data center where multiple processing facilities exist. The intent is to seamlessly redistribute load on an as required basis, transparent to the user community. These distributions are used on a localized or worldwide basis. Many companies use GSLB in its simplest form. They use the technology to automatically redirect traffic to Disaster Recovery (DR) sites on an exception basis. That is, GSLB is configured to simply route user load to the DR site on a temporary basis

only in the event of a catastrophic failure or only during extended planned data center maintenance. GSLB is also used to distribute load across data centers on a continuous load balancing basis as part of normal processing.

NetScaler and XenDesktop Deployment Guide: Link

Several of the management components of the XenDesktop stack are made highly-available using NetScaler to load balance traffic. The following management components require the use of a load balancer to function in a high availability mode:

- StoreFront Servers
- Licensing Server
- XenDesktop XML Service
- XenDesktop Desktop Director
- Provisioning Services TFTP Service
- Framehawk UDP virtual channel (supported on NetScaler Gateway 11.0.62.10 or later and NetScaler Unified Gateway 11.0.64.34 or later)



4.4 NVIDIA GRID vGPU

NVIDIA GRID vGPU™ brings the full benefit of NVIDIA hardware-accelerated graphics to virtualized solutions. This technology provides exceptional graphics performance for virtual desktops equivalent to local PCs when sharing a GPU among multiple users.

GRID vGPU is the industry's most advanced technology for sharing true GPU hardware acceleration between multiple virtual desktops—without compromising the graphics experience. Application features and compatibility are exactly the same as they would be at the user's desk.

With GRID vGPU technology, the graphics commands of each virtual machine are passed directly to the GPU, without translation by the hypervisor. This allows the GPU hardware to be time-sliced to deliver the ultimate in shared virtualized graphics performance.

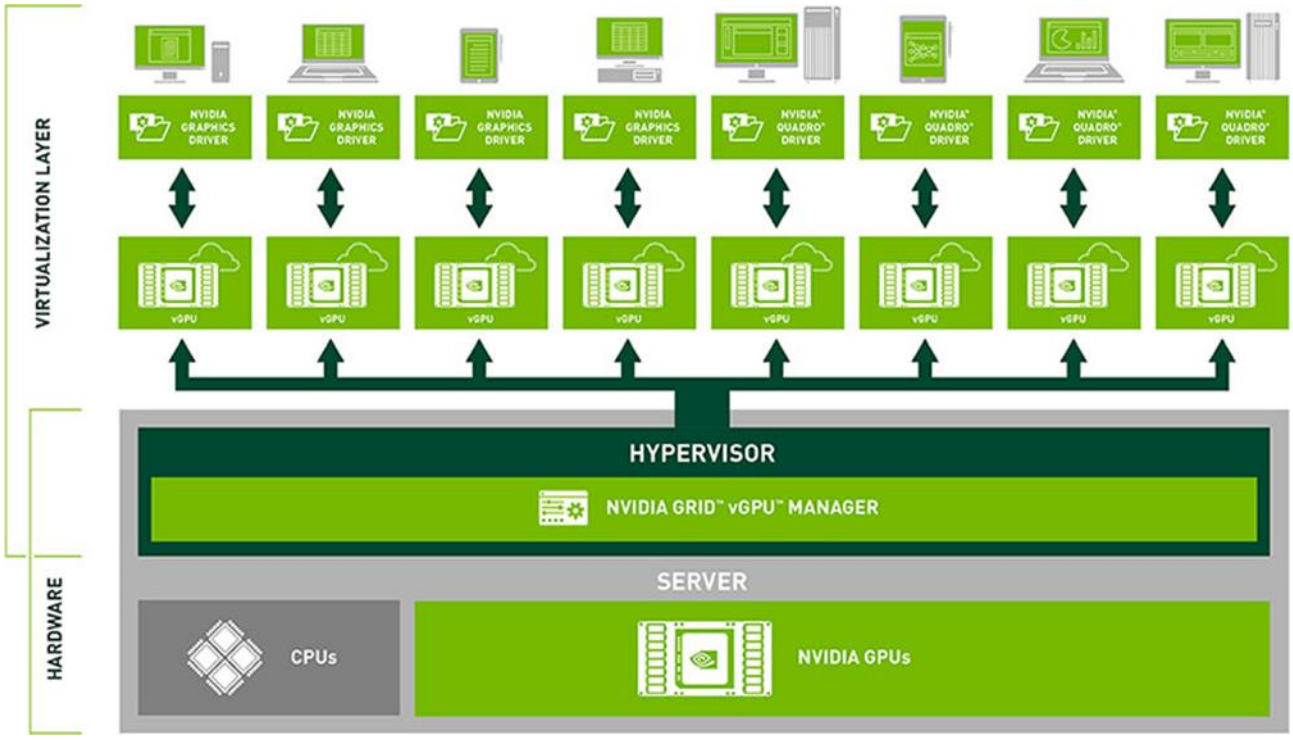


Image provided courtesy of NVIDIA Corporation, Copyright NVIDIA Corporation

4.5 vGPU Profiles

Virtual Graphics Processing Unit, or GRID vGPU™, is technology developed by NVIDIA® that enables hardware sharing of graphics processing for virtual desktops. This solution provides a hybrid shared mode allowing the GPU to be virtualized while the virtual machines run the native NVIDIA video drivers for better performance. Thanks to OpenGL support, VMs have access to more graphics applications. When utilizing vGPU, the graphics commands from virtual machines are passed directly to the GPU without any hypervisor translation. All this is done without sacrificing server performance and so is truly cutting edge.

The combination of Dell servers, NVIDIA GRID vGPU™ technology and NVIDIA GRID™ cards enable high-end graphics users to experience high fidelity graphics quality and performance, for their favorite applications at a reasonable cost. For more information about NVIDIA GRID vGPU, please visit this link.

The number of users per server is determined by the number of GPU cards in the system (max 2 x M10 or 3 x M60), vGPU profiles used for each GPU in a card and GRID license type. The same profile must be used on a single GPU but profiles can differ across GPUs in a single card.

NVIDIA Tesla M10 GRID vGPU Profiles:

Card	vGPU Profile	Graphics Memory (Frame Buffer)	Virtual Display Heads	Maximum Resolution	Maximum Graphics-Enabled VMs		
					Per GPU	Per Card	Per Server (2 cards)
Tesla M10	M10-8Q	8GB	4	4096x2160	1	4	8
	M10-4Q	4GB	4	4096x2160	2	8	16
	M10-2Q	2GB	4	4096x2160	4	16	32
	M10-1Q	1GB	2	4096x2160	8	32	64
	M10-0Q	512MB	2	2560x1600	16	64	128
	M10-1B	1GB	4	2560x1600	8	32	64
	M10-0B	512MB	2	2560x1600	16	64	128
	M10-8A	8GB	1	1280x1024	1	4	8
	M10-4A	4GB			2	8	16
	M10-2A	2GB			4	16	32
	M10-1A	1GB			8	32	64

Card	vGPU Profile	Guest VM OS Supported*		GRID License Required
		Win	64bit Linux	
Tesla M10	M10-8Q	●	●	NVIDIA® Quadro® Virtual Data Center Workstation
	M10-4Q	●	●	
	M10-2Q	●	●	
	M10-1Q	●	●	
	M10-0Q	●	●	
	M10-1B	●		GRID Virtual PC
	M10-0B	●		
	M10-8A	●		GRID Virtual Application
	M10-4A	●		
	M10-2A	●		
	M10-1A	●		

Supported Guest VM Operating Systems*	
Windows	**Linux**
Windows 7 (32/64-bit)	RHEL 6.6 & 7
Windows 8.x (32/64-bit)	CentOS 6.6 & 7
Windows 10 (32/64-bit)	Ubuntu 12.04 & 14.04 LTS
Windows Server 2008 R2	
Windows Server 2012 R2	
Windows Server 2016	

*NOTE: Supported guest operating systems listed as of the time of this writing. Please refer to NVIDIA's documentation for latest supported operating systems.

NVIDIA Tesla M60 GRID vGPU Profiles:

Card	vGPU Profile	Graphics Memory (Frame Buffer)	Virtual Display Heads	Maximum Resolution	Maximum Graphics-Enabled		
					Per GPU	Per Card	Per Server (3 cards)
Tesla M60	M60-8Q	8GB	4	4096x2160	1	2	6
	M60-4Q	4GB	4	4096x2160	2	4	12
	M60-2Q	2GB	4	4096x2160	4	8	24
	M60-1Q	1GB	2	4096x2160	8	16	48
	M60-0Q	512MB	2	2560x1600	16	32	96
	M60-1B	1GB	4	2560x1600	8	16	48
	M60-0B	512MB	2	2560x1600	16	32	96
	M60-8A	8GB	1	1280x1024	1	2	6
	M60-4A	4GB			2	4	12
	M60-2A	2GB			4	8	24
	M60-1A	1GB			8	16	48

Card	vGPU Profile	Guest VM OS Supported*		GRID License Required
		Win	64bit Linux	
Tesla M60	M60-8Q	●	●	NVIDIA® Quadro® Virtual Data Center Workstation
	M60-4Q	●	●	
	M60-2Q	●	●	
	M60-1Q	●	●	
	M60-0Q	●	●	
	M60-1B	●		GRID Virtual PC
	M60-0B	●		
	M60-8A	●		GRID Virtual Application
	M60-4A	●		
	M60-2A	●		
	M60-1A	●		

Supported Guest VM Operating Systems*	
Windows	**Linux**
Windows 7 (32/64-bit)	RHEL 6.6 & 7
Windows 8.x (32/64-bit)	CentOS 6.6 & 7
Windows 10 (32/64-bit)	Ubuntu 12.04 & 14.04 LTS
Windows Server 2008 R2	
Windows Server 2012 R2	
Windows Server 2016	

*NOTE: Supported guest operating systems listed as of the time of this writing. Please refer to NVIDIA's documentation for latest supported operating systems.

4.5.1 GRID vGPU Licensing and Architecture

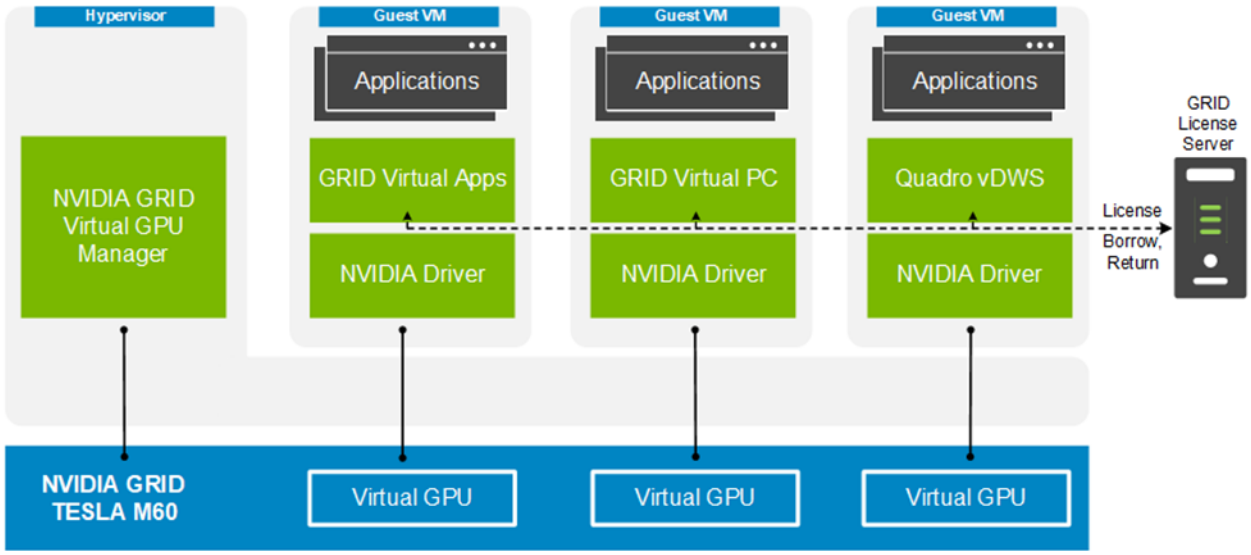
NVIDIA GRID vGPU is offered as a licensable feature on Tesla® GPUs. vGPU can be licensed and entitled using one of the three following software editions. vGPU is licensed with vSphere Enterprise Plus.

NVIDIA® GRID® Virtual Applications	NVIDIA® GRID® Virtual PC	NVIDIA® Quadro® Virtual Data Center Workstation
For organizations deploying RDSH solutions. Designed to deliver Windows applications at full performance.	For users who need a virtual desktop, but also need a great user experience leveraging PC applications, browsers, and high-definition video.	For users who need to use professional graphics applications with full performance on any device, anywhere.
Up to 2 displays @ 1280x1024 resolution supporting virtualized Windows applications	Up to 4 displays @ 2560x1600 resolution supporting Windows desktops, and NVIDIA Quadro features	Up to 4 displays @4096x2160* resolution supporting Windows or Linux desktops, NVIDIA Quadro, CUDA**, OpenCL** & GPU pass-through

*0Q profiles only support up to 2560x1600 resolution

**CUDA and OpenCL only supported with M10-8Q, M10-8A, M60-8Q, or M60-8A profiles

The GRID vGPU Manager, running on the hypervisor installed via the VIB, controls the vGPUs that can be assigned to guest VMs. A properly configured VM obtains a license from the GRID license server during the boot operation for a specified license level. The NVIDIA graphics driver running on the guest VM provides direct access to the assigned GPU. When the VM is shut down, it releases the license back to the server. If a vGPU enabled VM is unable to obtain a license, it will run at full capability without the license but users will be warned each time it tries and fails to obtain a license.



5 Solution architecture for Dell EMC VxRail Appliance with XenDesktop

5.1 Management server infrastructure

There is the option to use and existing Virtual Center during the VxRail Appliance deployment but the sizing information below shows the details of the VC appliance and PSC that will be deployed during the factory install.

Role	vCPU	RAM (GB)	NIC	OS + Data vDisk (GB)	Tier 2 Volume (GB)
VMware vCenter Appliance	2	16	1	290	
DDC + License Server	4	8	1	40	-
Platform Services Controller	2	2	1	30	
SQL Server	5	8	1	40	210 (VMDK)
File Server	1	4	1	40	2048 (VMDK)
VxRail Appliance Manager	2	8	1	32	
Log Insight	4	8	1	530	
Total	**20 vCPU**	**54GB**	**7 vNICs**	**1002GB**	**2258GB**

5.1.1 RDSH VM Configuration

The recommended number of RDSH VMs and their configurations on ESXi are summarized below and take into account proper NUMA balancing assuming the CPU. The amount of RDSH VMs per Server depend on the CPU configuration and for more information on NUMA please refer to the NUMA Architecture Considerations section.

RDSH VM configuration on ESXi

Role	vCPU	RAM (GB)	NIC	OS vDisk (GB)	Tier 2 Volume (GB)
RDSH VM	8	32	1	80	-

5.1.2 NVIDIA GRID License Server Requirements

When using NVIDIA Tesla cards, graphics enabled VMs must obtain a license from a GRID License server on your network to be entitled for vGPU. To configure, a virtual machine with the following specifications must be added to a management host in addition to the management role VMs.

Role	vCPU	RAM (GB)	NIC	OS + Data vDisk (GB)	Tier 2 Volume (GB)
NVIDIA GRID License Srv	2	4	1	40 + 5	-

GRID License server software can be installed on a system running the following operating systems:

- Windows 7 (x32/x64)
- Windows 8.x (x32/x64)
- Windows 10 x64
- Windows Server 2008 R2
- Windows Server 2012 R2
- Red Hat Enterprise 7.1 x64
- CentOS 7.1 x64

Additional license server requirements:

- A fixed (unchanging) IP address. The IP address may be assigned dynamically via DHCP or statically configured, but must be constant.
- At least one unchanging Ethernet MAC address, to be used as a unique identifier when registering the server and generating licenses in NVIDIA's licensing portal.
- The date/time must be set accurately (all hosts on the same network should be time synchronized).

5.1.3 SQL databases

The VMware databases are hosted by a single dedicated SQL 2016 (or higher) Server VM in the Management layer. Use caution during database setup to ensure that SQL data, logs, and TempDB are properly separated onto their respective volumes. Create databases for:

- Citrix XenDesktop
- vCenter

Initial placement of all databases into a single SQL instance is fine unless performance becomes an issue, in which case database need to be separated into separate named instances. Enable auto-growth for each DB.

Best practices defined by Citrix, Microsoft and VMware are to be adhered to, to ensure optimal database performance.

Align all disks to be used by SQL Server with a 1024K offset and then formatted with a 64K file allocation unit size (data, logs and TempDB).

5.1.4 DNS

DNS plays a crucial role in the environment not only as the basis for Active Directory but will be used to control access to the various VMware software components. All hosts, VMs and consumable software components need to have a presence in DNS, preferably via a dynamic and AD-integrated namespace. Microsoft best practices and organizational requirements are to be adhered to.

Pay consideration for eventual scaling, access to components that may live on one or more servers (SQL databases, VMware services) during the initial deployment. Use CNAMEs and the round robin DNS mechanism to provide a front-end “mask” to the back-end server actually hosting the service or data source.

5.1.4.1 DNS for SQL

To access the SQL data sources, either directly or via ODBC, a connection to the server name\ instance name must be used. To simplify this process, as well as protect for future scaling (HA), instead of connecting to server names directly, alias these connections in the form of DNS CNAMEs. So instead of connecting to SQLServer1\<instance name> for every device that needs access to SQL, the preferred approach is to connect to <CNAME>\<instance name>.

For example, the CNAME “VDISQL” is created to point to SQLServer1. If a failure scenario was to occur and SQLServer2 would need to start serving data, we would simply change the CNAME in DNS to point to SQLServer2. No infrastructure SQL client connections would need to be touched.

SQLServer1	Host (A)	10.1.1.28
SQLServer2	Host (A)	10.1.1.29
SQLVDI	Alias (CNAME)	SQLServer1.fcs.local

5.2 Storage architecture overview

All Dell EMC VxRail Appliances come with two tiers of local storage by default, SSD for performance and SSD or HDD for capacity depending on if it’s a Hybrid or All-Flash configuration. These disk groups need a minimum of 1 x cache device and 1 x capacity device per disk group. These local storage disk groups are configured into one Software Defined Storage pool via VSAN which are shared across all hosts in the VSAN Cluster.

5.2.1 VMware vSAN local storage

VMware vSAN is enabled and configured during the VxRail Appliance deployment so there is no manual configuration of vSAN needed with VxRail Appliance.

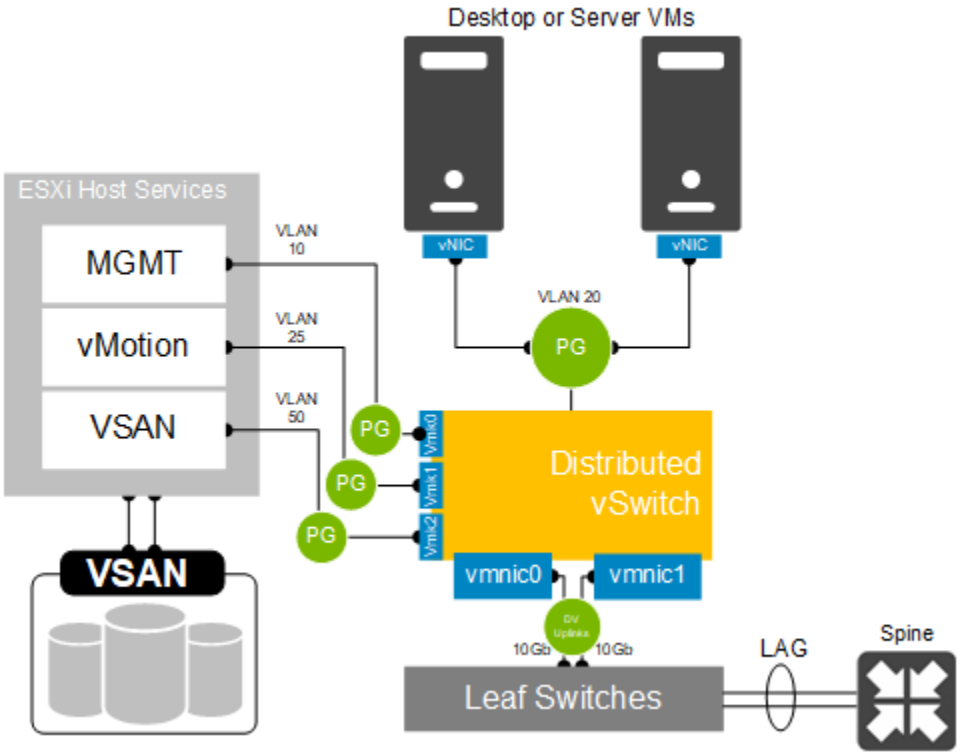
5.3 Virtual Networking

5.3.1 Dell EMC VxRail Appliance network configuration

The network configuration for the Dell EMC VxRail Appliances utilizes a 10 GbE converged infrastructure model. All required VLANs will traverse 2 x 10 GbE NICs configured in an active/ active team. For larger scaling it is recommended to separate the infrastructure management VMs from the compute VMs to aid in predictable compute host scaling. The following outlines the VLAN requirements for the Compute and Management hosts in this solution model:

- VxRail Appliance VLAN configuration
  - Management VLAN: Configured for hypervisor infrastructure traffic – L3 routed via core switch
  - VDI VLAN: Configured for VDI session traffic – L3 routed via core switch
  - VMware vSAN VLAN: Configured for VMware vSAN traffic – L2 switched only via ToR switch
  - vMotion VLAN: Configured for Live Migration traffic – L2 switched only, trunked from Core (HA only)
  - VDI Management VLAN: Configured for VDI infrastructure traffic – L3 routed via core switch
- A VLAN for iDRAC is configured for all hardware management traffic – L3 routed via core switch

The following screenshot shows the VMkernel adapter for the management network (vmk0), vMotion and VMware vSAN Network (vmk2) on a distributed switch.



5.3.1.1 vSphere Distributed Switches

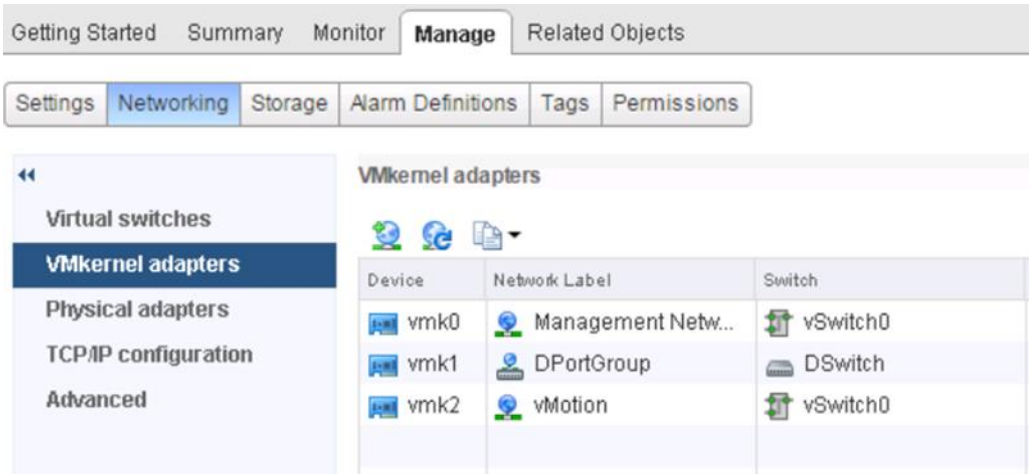
The benefit of using a VMware Distributed Switch (vDS) is that it brings a consistent configuration across all hosts. The vDS is configured at the vCenter level and provides central management and monitoring to all hosts configured on the vDS.

dvSwitches should be used as desired for VM traffic especially in larger deployments to ease the management burden across numerous hosts. In the VxRail Appliance rack model both the mgmt. hosts connect to shared storage so require additional VMK ports. Network share values should be configured equally among the VMkernel port groups that share a physical set of network adapters.

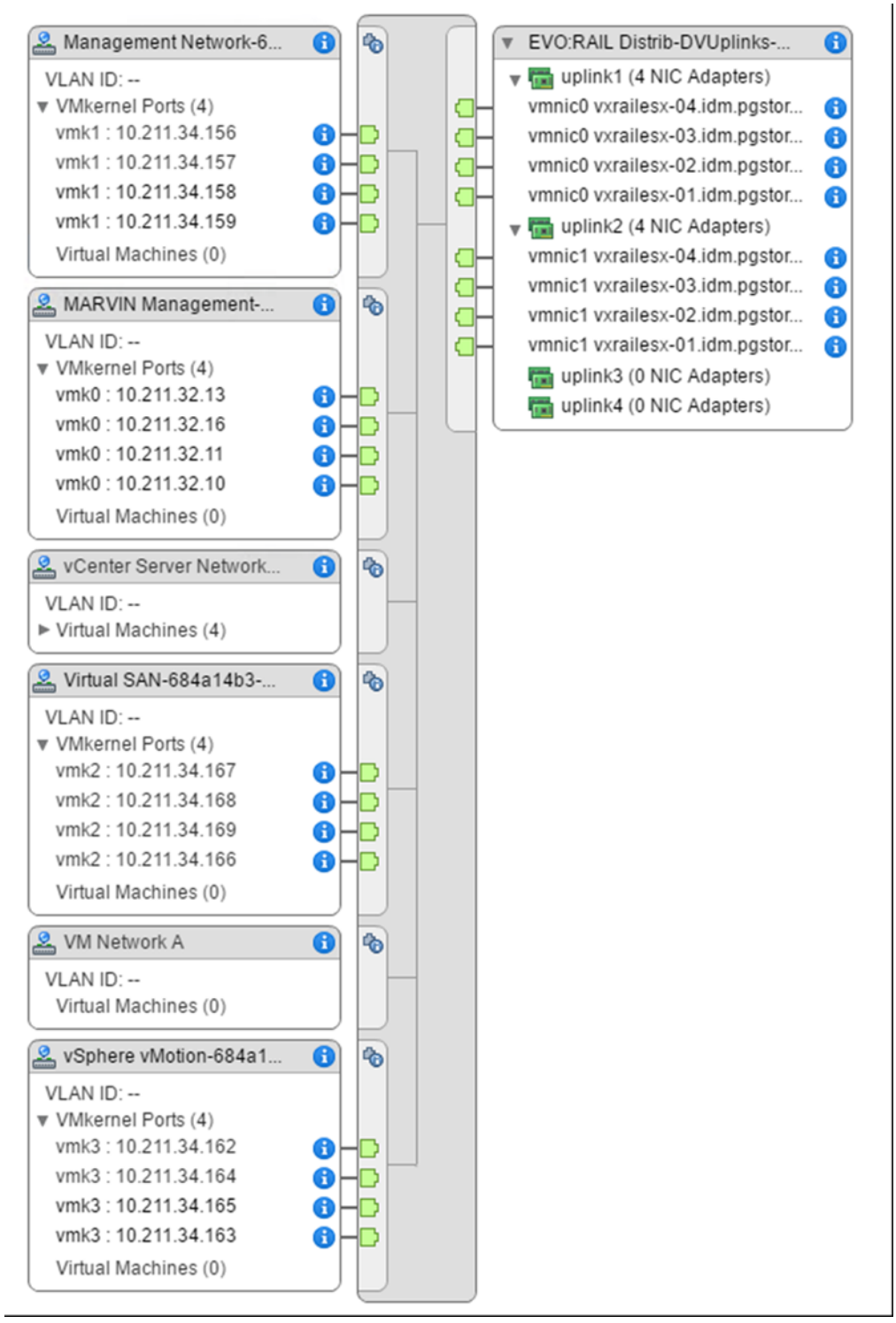
VMware vSAN cluster networking includes at least two VMkernel ports, one for management traffic and one for VMware vSAN traffic. If vMotion, Storage vMotion or High Availability functionality is required in addition, a third VMkernel port is to be configured for this.

VMware vSAN traffic can be used on 1 GbE networks as well as 10 GbE networks for Hybrid configuration but 10 GbE recommended and is required for All Flash configuration. Standard switch configuration can be used for Proof of Concept, while VMware distributed virtual switch configuration is highly recommended for production versions.

Network VMkernel adapter configuration for the host management traffic using a 10 GbE network with standard switch. It is recommended that the network configuration for the VMware vSAN storage is a 10 GbE network with distributed switch configuration.



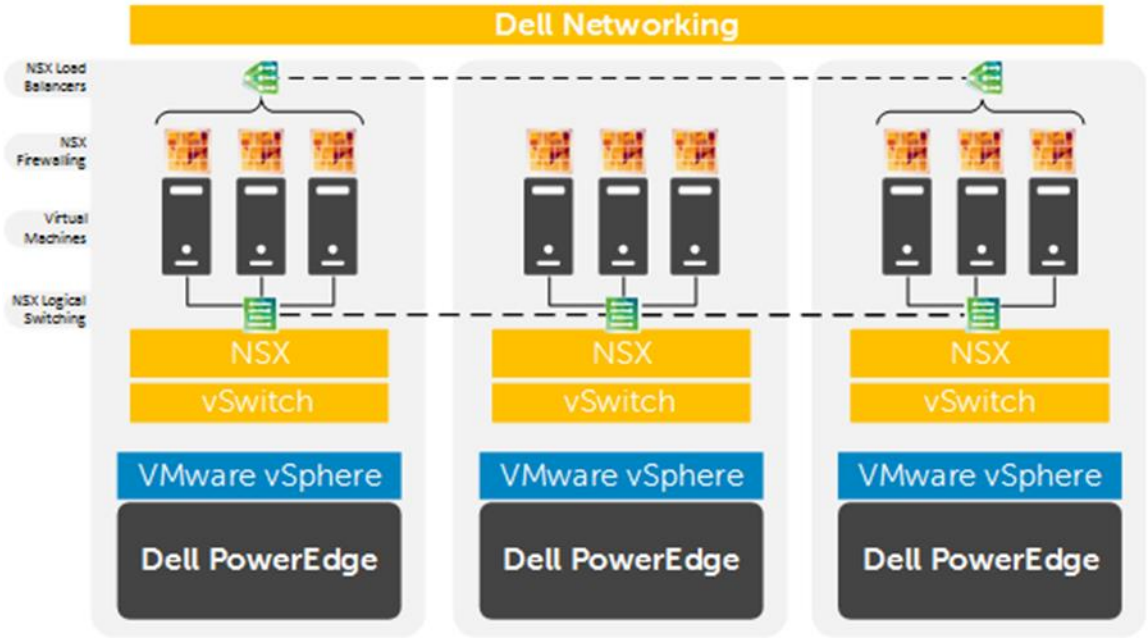
The distributed switch configuration is the same on all VxRail Appliance storage hosts. It is recommended to have at least two uplinks for each host to provide load balancing and fail back redundancy. The below image shows an example of a distributed switch configuration for VxRail Appliance.



5.3.2 VMware NSX

Dell and VMware's Software Defined Datacenter (SDDC) architecture goes beyond simply virtualizing servers and storage but also extends into the network. VMware NSX is a network virtualization platform deployable on any IP network that is integrated with vSphere Virtual Distributed Switching and provides the same features and benefits to networking as the ESXi hypervisor does to virtual machines. NSX provides a complete set of logical networking elements and services—including logical switching, routing, firewalling, load balancing, VPN, quality of service (QoS), and monitoring. These services are provisioned in virtual networks through any cloud management platform leveraging the NSX APIs. Through Dell's open networking, companies are best able to take advantage of this disaggregation of a virtual network overlay and an open physical underlay. Building a zero-trust security model is easy with NSX as each virtualized workload can be protected with a stateful firewall engine providing extreme policy granularity. Any VM in the datacenter can be rigorously secured or isolated if compromised, especially useful for virtual desktops to prevent malicious code from attacking and spreading through the network.

VMware NSX is implemented via a layered architecture consisting of data, control and management planes. The NSX vSwitch exists within and requires the vSphere Distributed Switch to abstract the physical network while proving access-level switching in the hypervisor. NSX enables the use of virtual load balancers, firewalls, logical switches and routers that can be implemented and scaled seamlessly to suit any deployed architecture. VMware NSX compliments Dell Networking components deployed ToR, leaf/spine or at the core.

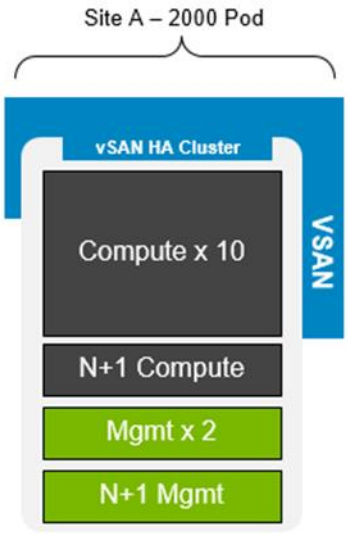


Key Features of Dell Open Networking and VMware NSX	
Power of Choice	Choose from best-of-breed open networking platforms, operating systems and applications.
Accelerated Innovation	Take advantage of open networking with open source standards-based tools and expertise to help accelerate innovation.
Open Networking Platform	All Dell Networking data center switches support the Open Network Install Environment (ONIE), allowing customers to choose between multiple operating systems and meet their unique needs.
Hardware VTEP Gateway	Layer 2 gateway through VXLAN Tunnel End Points (VTEP) bridges virtual and physical infrastructures.
Virtual Switching	VXLAN based network overlays enable logical layer 2 overlay extensions across a routed (L3) fabric within and across data center boundaries.
Virtual Routing	Dynamic routing between virtual networks performed in a distributed manner in the hypervisor kernel, and scale-out routing with active-active failover with physical routers.
Distributed Firewalling	Distributed stateful firewalling, embedded in the hypervisor kernel for up to 20 Gbps of firewall capacity per hypervisor host.
Load Balancing	L4-L7 load balancer with SSL offload and pass through, server health checks, and App Rules for programmability and traffic manipulation.

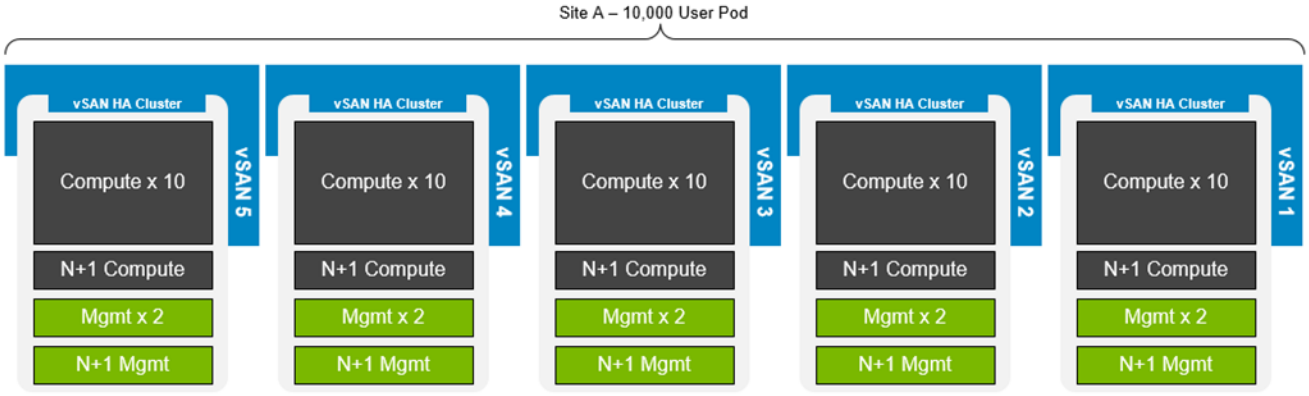
For more information on VMware NSX and integrated offers from Dell Networking please see the Dell Networking Solution Brief and the Reference architecture.

5.4 Scaling Guidance

The components are scaled either horizontally (by adding additional physical and virtual servers to each component of the solution architecture scales independently according to the desired number of supported users. Additional appliance nodes can be added at any time to expand the vSAN SDS pool in a modular fashion. The scaling limit for vSAN is restricted due to the limits of the Hypervisor so 64 Nodes in total per Cluster. The recommended limit by VMware with regards to the amount of VMs per Cluster is 2,000 so taking this into consideration we need 10 compute nodes for with 200 Task User VMs per Node. The image below shows a 2000 user vSAN Block.



The example below shows a scale out of a 10,000 user vSAN Pod with 2000 user blocks, each block contains its own Virtual Center.



- The components are scaled either horizontally (by adding additional physical and virtual servers to the server pools) or vertically (by adding virtual resources to the infrastructure)
- Eliminate bandwidth and performance bottlenecks as much as possible
- Allow future horizontal and vertical scaling with the objective of reducing the future cost of ownership of the infrastructure. The below table shows the scalability options for each component.

Component	Metric	Horizontal scalability	Vertical scalability
Compute Servers	Desktop VMs per physical host based on available CPU	Additional hosts and clusters added as necessary	Additional RAM or CPU compute power
Mgmt Servers	Number of server VMs per host	Add additional hosts	Add RAM or network adapters
Provisioning Servers	Desktops per instance	Additional servers added to the Provisioning Server farm	Additional network and I/O capacity added to the servers
Desktop Delivery Servers	Desktops per instance (dependent on SQL performance as well)	Additional servers added to the XenDesktop Site	Additional virtual machine resources (RAM and CPU)
XenApp Servers	Desktops per instance	Additional virtual servers added to the XenDesktop Site	Additional physical servers to host virtual XenApp servers.
Storefront Servers	Logons/ minute	Additional servers added to the Storefront environment	Additional virtual machine resources (RAM and CPU)
Database Services	Concurrent connections, responsiveness of reads/ writes	Migrate databases to a dedicated SQL server and increase the number of management nodes	Additional RAM and CPU for the management nodes
File Services	Concurrent connections, responsiveness of reads/ writes	Split user profiles and home directories between multiple file servers in the cluster. File services can also be migrated to the optional NAS device to provide high availability.	Additional RAM and CPU for the management nodes

5.5 Solution High Availability

High availability (HA) is offered to protect each layers of the solution architecture, individually if desired. Following the N+1 model, additional ToR switches for LAN, VMware vSAN are added to the Network layer and stacked to provide redundancy as required, additional compute and management hosts are added to their respective layers, vSphere clustering is introduced in the management layer, SQL is mirrored or clustered, an F5 device can be leveraged for load balancing.

The HA options provide redundancy for all critical components in the stack while improving the performance and efficiency of the solution as a whole.

Additional switches added to the existing thereby equally spreading each host's network connections across multiple switches.

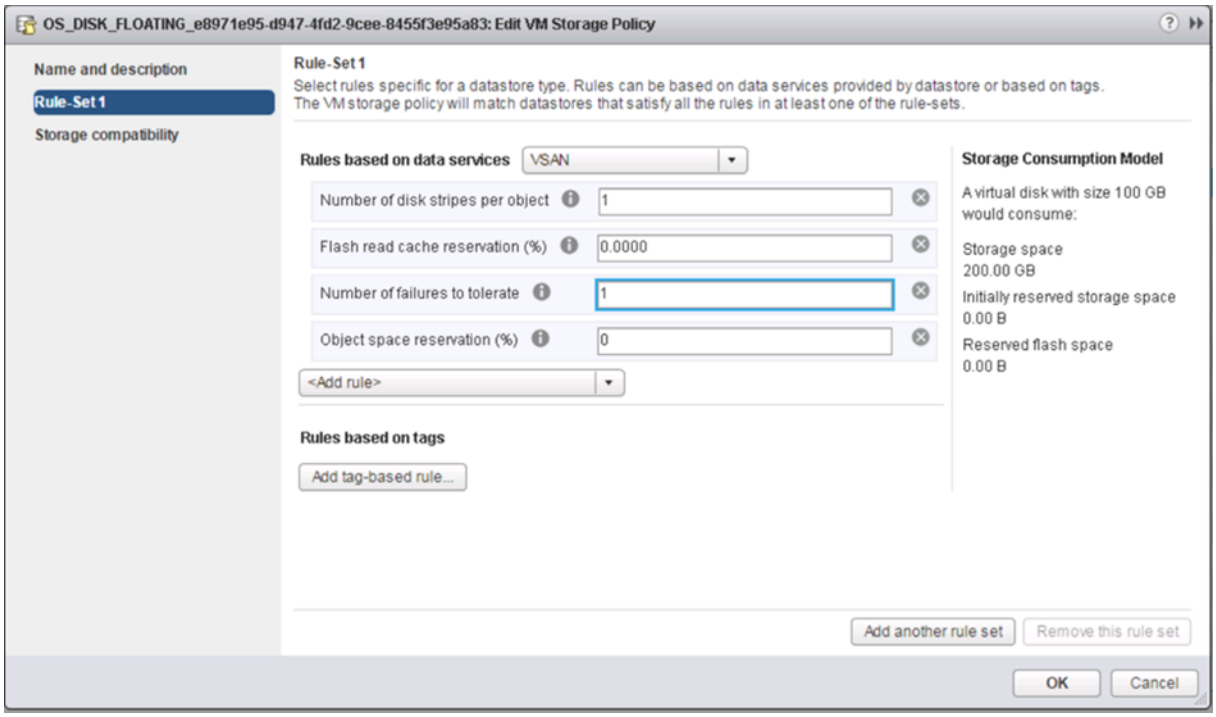
Additional ESXi hosts added in the compute or management layers to provide N+1 protection.

Applicable Citrix XenDesktop infrastructure server roles are duplicated and spread amongst management host instances where connections to each are load balanced via the addition of F5 appliances.

5.5.1 VMware vSAN HA/ FTT Configuration

The minimum configuration required for Dell EMC VxRail Appliance is 3 ESXi hosts. The issue with having a 3-Node cluster is if one node fails there is nowhere to rebuild the failed components, so 3 node clusters should be used only for POC or non-production.

The virtual machines that are deployed via VMware vSAN are policy driven and one of these policy settings is Number of failures to tolerate (FTT). The default value for FTT is FTT=1 so that will make a mirrored copy of the Virtual Machines VMDK, so if the VMDK is 40Gb in size then 80Gb of virtual machine space is needed.



The recommended configuration by VMware for a VMware vSAN Cluster with FTT=1 and RAID 1 is four nodes and this ensures that the virtual machines are fully protected during operational & maintenance activities. This configuration can also survive another failure even when there is a host already in maintenance mode.

5.5.2 vSphere HA

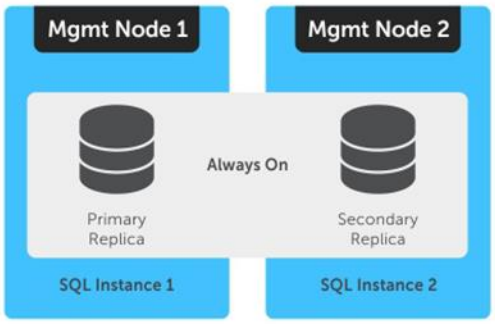
Both compute and management hosts are identically configured, within their respective tiers. The management Tier leverages the shared VMware vSAN storage so can make full use of vSphere HA and VxRail Appliance Compute nodes can be added to add HA to the configured storage policy. The hosts can be configured in an HA cluster following the boundaries of VMware vSAN 6.6 limits dictated by VMware (6,400 VMs per VMware vSAN Cluster). This will result in multiple HA clusters managed by multiple vCenter servers.

The number of supported VMs (200*) is a soft limit and this is discussed further in section 6 of this document.

VMware vSAN Limits	Minimum	Maximum
Number of supported ESXi hosts per VMware vSAN cluster	3	64
Number of supported VMs per host	n/a	200*
Number of supported VMs per VMware vSAN Cluster	n/a	6400
Disk groups per host	1	5
HDDs per disk group	1	7
SSDs per disk group	1	1
Components per host	n/a	9000
Components per object	n/a	64

5.5.3 SQL Server High Availability

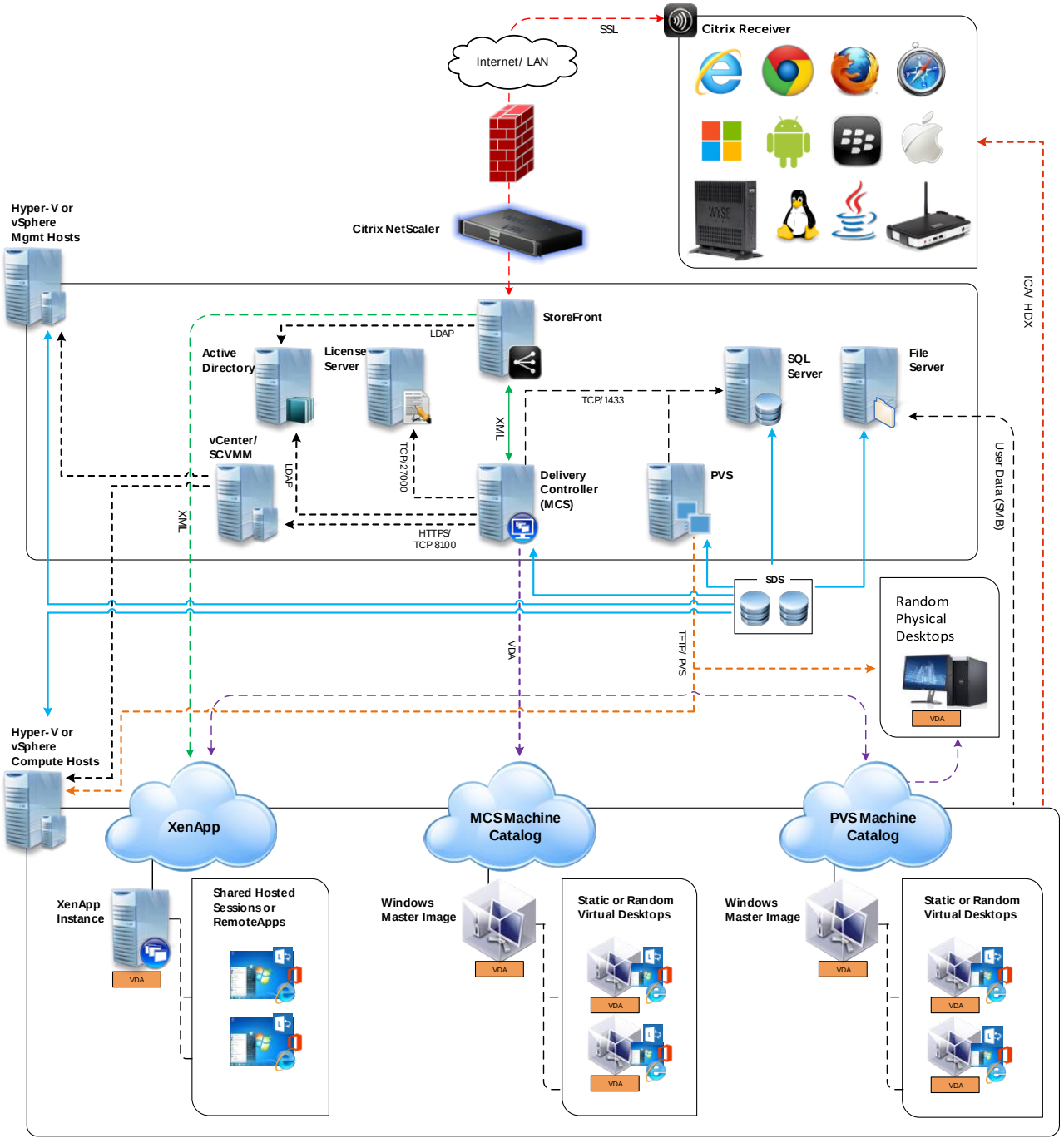
HA for SQL is provided via AlwaysOn using either Failover Cluster Instances or Availability Groups. This configuration protects all critical data stored within the database from physical server as well as virtual server problems. DNS is used to control access to the primary SQL instance. Place the principal VM that will host the primary copy of the data on the first Management host. Additional replicas of the primary database are placed on subsequent Management hosts.



Please refer to these links for more information: LINK1 and LINK2.

5.6 Citrix XenDesktop Communication Flow

The following diagram provides an overview of the communication flow within a XenDesktop environment.



6 Solution Performance and Testing

At the time of publication, here are the available density recommendations. The below user densities were achieved by following the VMware best practices of FTT=1 and a reserved slack space of 30%.

*The soft limit for the amount of VMs supported per host is 200, this is due to number of total objects that are supported per cluster. This is a factor in very large clusters but for small to medium Cluster configurations this should not be an issue. The hardware configuration details are listed here.

User density summary

Host Config	Hypervisor	Broker & Provisioning	Workload	Template	User Density
V570F B5	ESXi 6.5	XD 7.15, MCS linked clones	Task Worker	Windows 10 & Office 2016	210
V570F B5	ESXi 6.5	XD 7.15, MCS linked clones	Knowledge Worker	Windows 10 & Office 2016	140
V570F B5	ESXi 6.5	XD 7.15, MCS linked clones	Power Worker	Windows 10 & Office 2016	120

Dell EMC is aware of the new side-channel analysis vulnerabilities, known as Meltdown and Spectre, affecting many modern microprocessors that were discovered and published by a team of security researchers on January 3, 2018. Further information is available at the following locations:

- https://emcservice--c.na55.visual.force.com/apex/KB_Security_KB?id=kA6f1000000FD0g
- http://www.dell.com/support/article/SLN308588
- http://www.dell.com/support/article/SLN308587

The detailed validation results and analysis of these reference designs are in the next section, this section covers the knowledge worker results. The user density numbers for Task & Power user have been leveraged from the 14G vSRN Citrix XenDesktop RA results with both using the same software and hardware configurations the user density per compute host is the same. The 14G vSRN RA is located here.

6.1 Test and Performance Analysis Methodology

6.1.1 Testing Process

To ensure the optimal combination of end-user experience (EUE) and cost-per-user, performance analysis and characterization (PAAC) on Dell Wyse Datacenter solutions is carried out using a carefully designed, holistic methodology that monitors both hardware resource utilization parameters and EUE during load-testing.

Login VSI is currently the load-generation tool used during PAAC of Dell Wyse Datacenter solutions. Each user load is tested against four runs. First, a pilot run to validate that the infrastructure is functioning and valid data can be captured, and then, three subsequent runs allowing correlation of data.

At different times during testing, the testing team will complete some manual "User Experience" Testing while the environment is under load. This will involve a team member logging into a session during the run and completing tasks similar to the User Workload description. While this experience will be subjective, it will help provide a better understanding of the end user experience of the desktop sessions, particularly under high load, and ensure that the data gathered is reliable.

6.1.1.1 Load Generation

Login VSI by Login Consultants is the de-facto industry standard tool for testing VDI environments and server-based computing (RDSH environments). It installs a standard collection of desktop application software (e.g. Microsoft Office, Adobe Acrobat Reader) on each VDI desktop; it then uses launcher systems to connect a specified number of users to available desktops within the environment. Once the user is connected, the workload is started via a logon script which starts the test script once the user environment is configured by the login script. Each launcher system can launch connections to a number of 'target' machines (i.e. VDI desktops). The launchers and Login VSI environment are configured and managed by a centralized management console.

Additionally, the following login and boot paradigm is used:

- Users are logged in within a login timeframe of 1 hour. Exception to this login timeframe occurs when testing low density solutions such as GPU/graphics based configurations. With those configurations, users are logged on every 10-15 seconds.
- All desktops are pre-booted in advance of logins commencing.
- All desktops run an industry-standard anti-virus solution. Windows Defender is used for Windows 10 due to issues implementing McAfee.

6.1.1.2 Profiles and Workloads

It's important to understand user workloads and profiles when designing a desktop virtualization solution in order to understand the density numbers that the solution can support. At Dell, we use five workload / profile levels, each of which is bound by specific metrics and capabilities with two targeted at graphics-intensive use cases. We will present more detailed information in relation to these workloads and profiles below but first it is useful to define the terms "profile" and "workload" as they are used in this document.

Profile: This is the configuration of the virtual desktop - number of vCPUs and amount of RAM configured on the desktop (i.e. available to the user).

Workload: This is the set of applications used by performance analysis and characterization (PAAC) of Dell Wyse Datacenter solutions (e.g. Microsoft Office applications, PDF Reader, Internet Explorer etc.)

Load-testing on each profile is carried out using an appropriate workload that is representative of the relevant use case and summarized in the table below:

Profile to workload mapping

Profile Name	Workload
Task Worker	Login VSI Task worker
Knowledge Worker	Login VSI Knowledge worker
Power Worker	Login VSI Power worker
Graphics LVSI Power + ProLibrary	Graphics - Login VSI Power worker with ProLibrary
Graphics LVSI Custom	Graphics – LVSI Custom

Login VSI workloads are summarized in the sections below. Further information for each workload can be found on Login VSI's website.

Login VSI Task Worker Workload

The Task Worker workload runs fewer applications than the other workloads (mainly Excel and Internet Explorer with some minimal Word activity, Outlook, Adobe, copy and zip actions) and starts/stops the applications less frequently. This results in lower CPU, memory and disk IO usage.

Login VSI Knowledge Worker Workload

The Knowledge Worker workload is designed for virtual machines with 2vCPUs. This workload and contains the following activities:

- Outlook, browse messages.
- Internet Explorer, browse different webpages and a YouTube style video (480p movie trailer) is opened three times in every loop.
- Word, one instance to measure response time, one instance to review and edit a document.
- Doro PDF Printer & Acrobat Reader, the Word document is printed and exported to PDF.
- Excel, a very large randomized sheet is opened.
- PowerPoint, a presentation is reviewed and edited.
- FreeMind, a Java based Mind Mapping application.
- Various copy and zip actions.

Login VSI Power Worker Workload

The Power Worker workload is the most intensive of the standard workloads. The following activities are performed with this workload:

- Begins by opening four instances of Internet Explorer which remain open throughout the workload.
- Begins by opening two instances of Adobe Reader which remain open throughout the workload.
- There are more PDF printer actions in the workload as compared to the other workloads.
- Instead of 480p videos a 720p and a 1080p video are watched.
- The idle time is reduced to two minutes.
- Various copy and zip actions.

Graphics - Login VSI Power Worker with ProLibrary workload

For lower performance graphics testing where lower amounts of graphics memory are allocated to each VM, the Power worker + Pro Library workload is used. The Login VSI Pro Library is an add-on for the Power worker workload which contains extra content and data files. The extra videos and web content of the Pro Library utilizes the GPU capabilities without overwhelming the lower frame buffer assigned to the desktops. This type of workload is typically used with high density vGPU and sVGA or other shared graphics configurations.

Graphics – LVSI Custom workload

This is a custom Login VSI workload specifically for higher performance, intensive graphics testing. For this workload, SPECwpc benchmark application is installed to the client VMs. During testing, a script is started that launches SPECwpc which executes the Maya and sw-03 modules for high performance tests and module sw-03 only for high density tests. The usual activities such as Office application execution are not performed with this workload. This type of workload is typically used for lower density/high performance pass-through, vGPU, and other dedicated, multi-user GPU configurations.

6.1.2 Resource Monitoring

The following sections explain respective component monitoring used across all Dell Wyse Datacenter solutions where applicable.

6.1.2.1 GPU Resources

ESXi hosts

For gathering of GPU related resource usage, a script is executed on the ESXi host before starting the test run and stopped when the test is completed. The script contains NVIDIA System Management Interface commands to query each GPU and log GPU utilization and GPU memory utilization into a .csv file.

ESXi 6.5 and above includes the collection of this data in the vSphere Client/Monitor section. GPU processor utilization, GPU temperature, and GPU memory utilization can be collected the same was as host CPU, host memory, host Network, etc.

6.1.2.2 VMware vCenter

VMware vCenter is used for VMware vSphere-based solutions to gather key data (CPU, Memory, Disk and Network usage) from each of the compute hosts during each test run. This data is exported to .csv files for single hosts and then consolidated to show data from all hosts (when multiple are tested). While the report does not include specific performance metrics for the Management host servers, these servers are monitored during testing to ensure they are performing at an expected performance level with no bottlenecks.

6.1.3 Resource Utilization

Poor end-user experience is one of the main risk factors when implementing desktop virtualization but a root cause for poor end-user experience is resource contention: hardware resources at some point in the solution have been exhausted, thus causing the poor end-user experience. In order to ensure that this does not happen, PAAC on Dell Wyse Datacenter solutions monitors the relevant resource utilization parameters and applies relatively conservative thresholds as shown in the table below. Thresholds are carefully selected to deliver an optimal combination of good end-user experience and cost-per-user, while also providing burst capacity for seasonal / intermittent spikes in usage. Utilization within these thresholds is used to determine the number of virtual applications or desktops (density) that are hosted by a specific hardware environment (i.e. combination of server, storage and networking) that forms the basis for a Dell Wyse Datacenter RA

Resource utilization thresholds

Parameter	Pass/Fail Threshold
Physical Host CPU Utilization	100%
Physical Host Memory Utilization	85%
Network Throughput	85%
Storage IO Latency	20ms

*Turbo mode is enabled; therefore, the CPU threshold is increased as it will be reported as over 100% utilization when running with turbo.

6.2 Test Configuration Details

The following components were used to complete the validation testing for the solution:

Hardware and software test components.

Component	Description/Version
Hardware platform(s)	VxRail Appliance V570F B5
Hypervisor(s)	ESXi 6.5
Broker technology	XenDesktop 7.15
Broker database	Microsoft SQL 2016
Management VM OS	Windows Server 2012 R2 (Connection Server & Database)
Virtual desktop OS	Windows 10 Enterprise
Office application suite	Office Professional 2016
Login VSI test suite	Version 4.1

6.2.1 Compute VM configurations

The following table summarizes the compute VM configurations for the various profiles/workloads tested.

Desktop VM specifications

User Profile	vCPUs	ESXi Memory Configured	ESXi Memory Reservation	Screen Resolution	Operating System
Task Worker	1	2GB	1GB	1280 X 720	Windows 10 Enterprise 64-bit
Knowledge Worker	2	3GB	1.5GB	1920 X 1080	Windows 10 Enterprise 64-bit
Power Worker	2	4GB	2GB	1920 X 1080	Windows 10 Enterprise 64-bit
Graphics LVSI Power + ProLibrary	2	4 GB	4GB	1920 X 1080	Windows 10 Enterprise 64-bit
Graphics LVSI Custom – Density	2	4 GB	4GB	1920 X 1080	Windows 10 Enterprise 64-bit
Graphics LVSI Custom - Performance	4	8GB	8GB	1920 X 1080	Windows 10 Enterprise 64-bit

6.3 Test results and analysis

The following table summarizes the test results for the compute hosts using the various workloads and configurations. Refer to the prior section for platform configuration details.

Test result summary

Platform Config	Hypervisor	Broker & Provisioning	Login VSI Workload	Density Per Host	Avg CPU	Avg Mem Consumed	Avg Mem Active	Avg IOPS / User
V570F-B5	ESXi 6.5	XD 7.15, MCS linked clones	Task Worker	210	98%	378GB	241GB	25
V570F-B5	ESXi 6.5	XD 7.15, MCS linked clones	Knowledge Worker	140	97.7%	377GB	223GB	17.9
V570F-B5	ESXi 6.5	XD 7.15, MCS linked clones	Power Worker	120	98%	378GB	227GB	24

Density per Host: Density reflects number of users per compute host that successfully completed the workload test within the acceptable resource limits for the host. For clusters, this reflects the average of the density achieved for all compute hosts in the cluster.

Avg CPU: This is the average CPU usage over the steady state period. For clusters, this represents the combined average CPU usage of all compute hosts. On the latest Intel series processors, the ESXi host CPU metrics will exceed the rated 100% for the host if Turbo Boost is enabled (by default). An additional 35% of CPU is available from the Turbo Boost feature but this additional CPU headroom is not reflected in the VMware vSphere metrics where the performance data is gathered. Therefore, CPU usage for ESXi hosts is adjusted and a line indicating the potential performance headroom provided by Turbo boost is included in each CPU graph.

Avg Consumed Memory: Consumed memory is the amount of host physical memory consumed by a virtual machine, host, or cluster. For clusters, this is the average consumed memory across all compute hosts over the steady state period.

Avg Mem Active: For ESXi hosts, active memory is the amount of memory that is actively used, as estimated by VMkernel based on recently touched memory pages. For clusters, this is the average amount of guest “physical” memory actively used across all compute hosts over the steady state period.

Avg IOPS/User: IOPS calculated from the average Disk IOPS figure over the steady state period divided by the number of users.

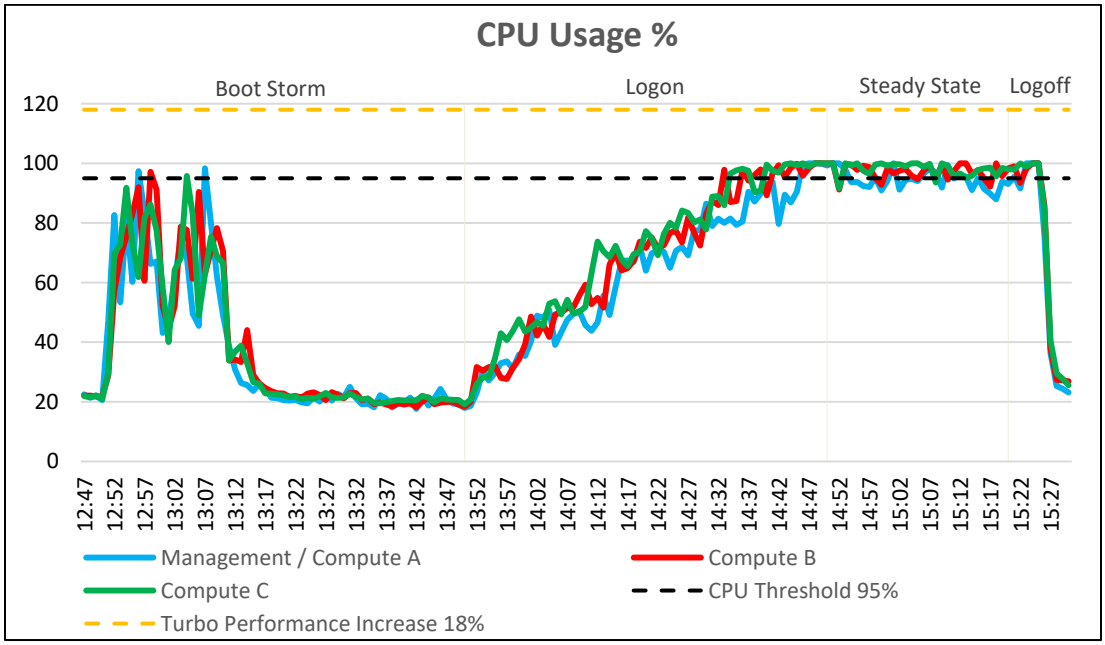
Avg Net Mbps/User: Amount of network usage over the steady state period divided by the number of users. For clusters, this is the combined average of all compute hosts over the steady state period divided by the number of users on a host.

6.3.1 VxRail V570F B5

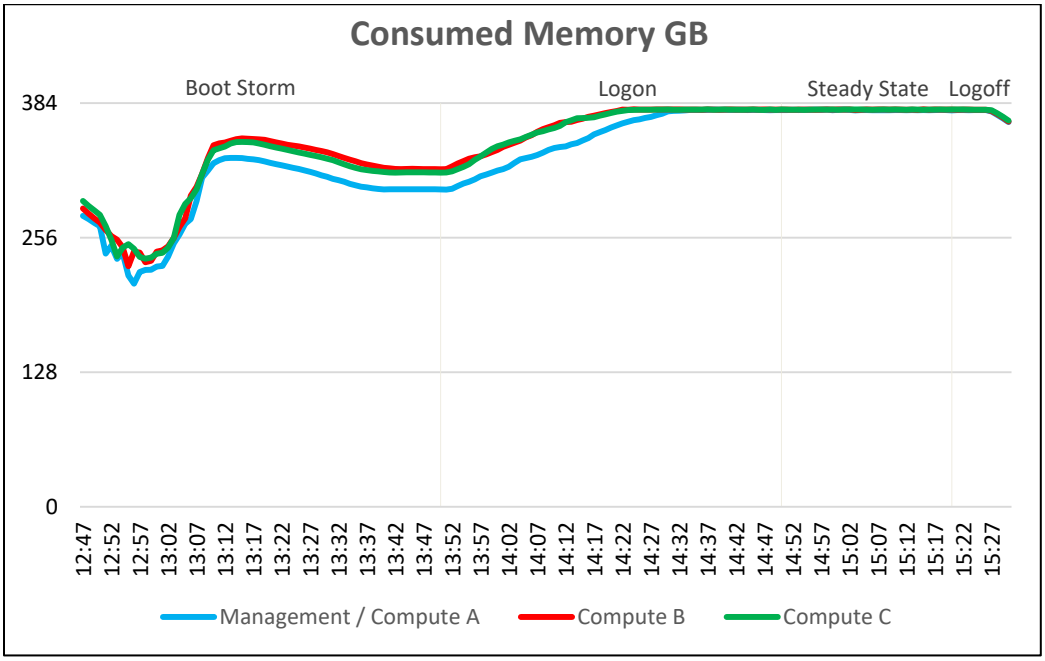
6.3.1.1 Knowledge Worker, 140 users, ESXi 6.5, XD 7.15, MCS Linked Clones

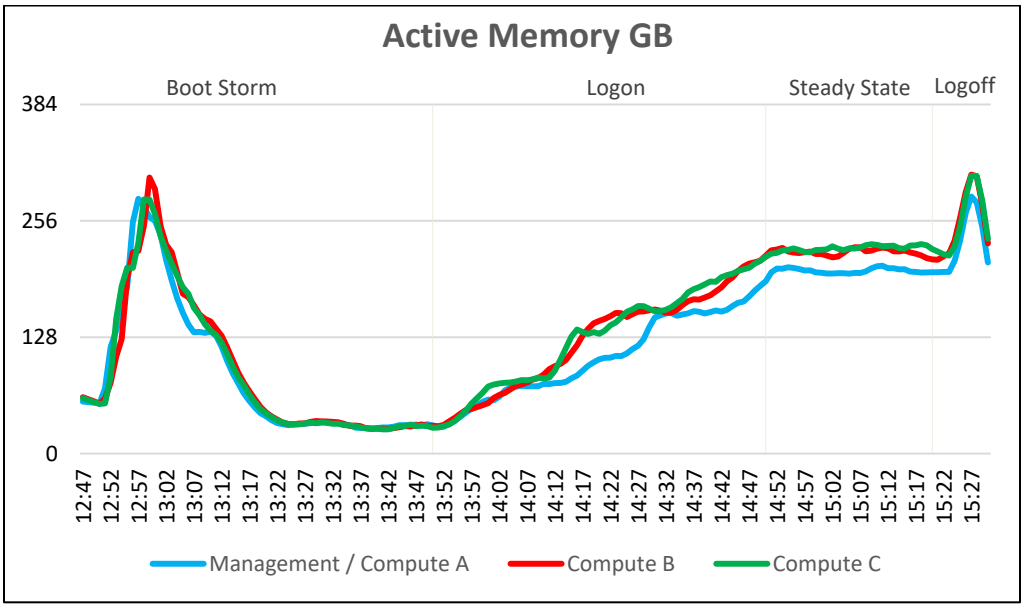
Each compute host was populated with 140 virtual machines per host and the combined Management / Compute host was populated with 130 user vm's. The combined Management / Compute host also hosted the VxRail Manager VM, vCenter VM and a Platform Services Controller VM. With all user virtual machines powered on and before starting test, the CPU usage was approximately 20% on the dedicated compute hosts. The CPU consumption of the management VM's was minimal during the testing period. We see that increasing the amount of VM's on the management host has an impact on the compute hosts user density, so even though we have 140 per compute host

The below graph shows the performance data for 140 user sessions per host. The CPU reaches a steady state average of 97.7% across the two compute hosts during the test cycle when 140 users were logged on to each compute host.

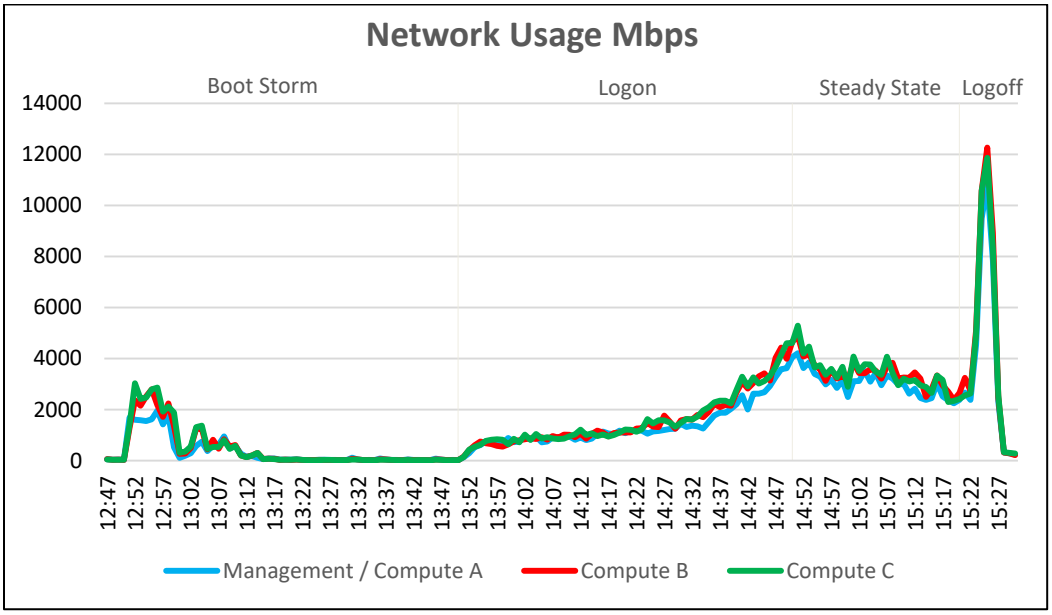


Regarding memory consumption for the cluster, out of a total of 384 GB available memory per node, memory usage was pushed close to its maximum. The compute hosts reached a maximum memory consumption of 378 GB with active memory usage reaching a max of 306 GB. Some ballooning occurred on the hosts which began approximately 20 minutes into the logon phase and ended during the logoff phase. The maximum amount of memory ballooning was approximately 46 GB. There was also some memory swapping on all the hosts, this reached a peak of 2.5 GB.



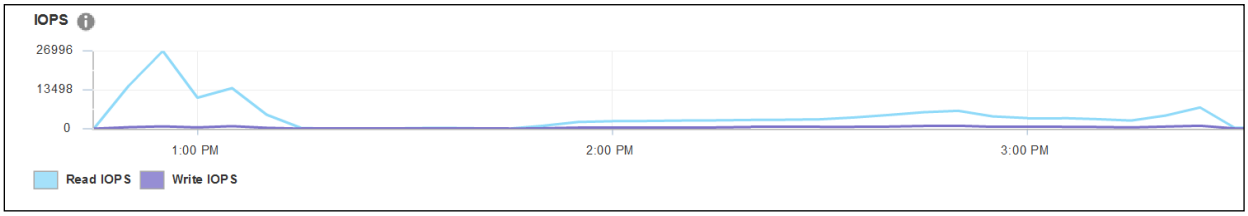


Network bandwidth is not an issue on this test run with a steady state peak of approximately 5,287 Mbps on the Compute hosts. The busiest period for network traffic was during logoff phase after testing had completed. One of the hosts reached a peak of 12,265 Mbps during the logoff phase at the end of testing.



The IOPS graphs and IOPS numbers are taken from the vCenter web console and the graphs clearly display the boot storm, the initial logon of the desktops then the steady state and finally the logoff phase. The graph displays the Disk IOPS figure for the VSAN cluster.

The cluster reached a maximum of 27,878 Disk IOPS during the reboot of all the VM's before test start and 7,340 IOPS at the start of steady state.



Disk I/O Latency was not an issue during the Login VSI testing period of this test run. The maximum latency reached was approximately 22 ms during the logoff phase and 7 ms at the beginning of steady state. This steady state number was well below the 20 ms threshold that is regarded as becoming potentially troublesome and the 22 ms figure was recorded while all the VM's were logging off together and so was to be somewhat expected.

The Login VSI Max user experience score shown below for this test was not reached. When manually interacting with the sessions during steady state the mouse and window movement was responsive and video playback was acceptable.