Dell XC Web-Scale Converged Appliance for VMware Horizon®

Dell Engineering
September 2015

A Dell Appliance Architecture

Revisions

Date	Description
March 2015	Initial release
Sep 2015	Document overhaul, XC730 + vGPU Addition

Contents

1 Introduction

1.1 Purpose

This document addresses the architecture design, configuration and implementation considerations for the key components required to deliver virtual desktops or shared sessions via VMware Horizon® on VMware vSphere® 6.

1.2 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 solution scaling and component selection guidance.

1.3 What's New

- Introduce support for VMware vSphere 6
- Introduce support for new Dell XC730 Graphics appliance
- Introduce support for NVIDIA GRID vGPU on vSphere 6

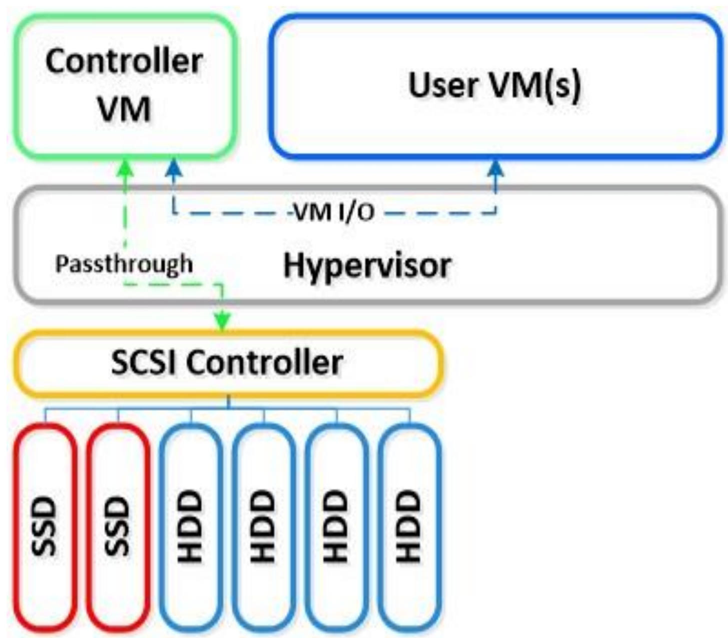
2 Solution Architecture Overview

2.1 Introduction

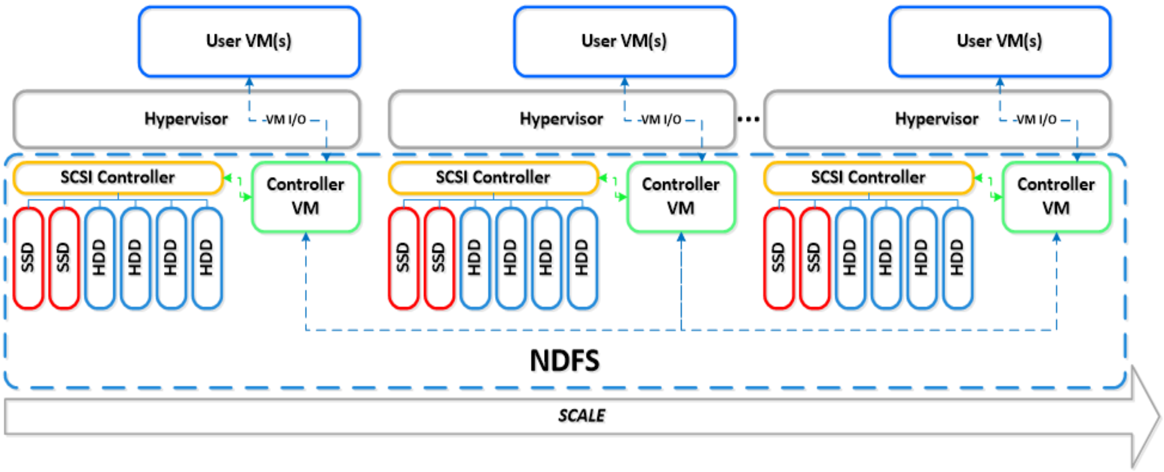
The Dell XC series delivers an out-of-the-box infrastructure solution for virtual desktops that eliminates the high cost, variable performance, and extensive risk of conventional solutions. The Nutanix™ web-scale converged infrastructure is a turnkey solution that comes ready to run your VDI solution of choice. The Nutanix platform's unique architecture allows enterprises to scale their virtual desktops from 50 to tens of thousands of desktops in a linear fashion, providing customers with a simple path to enterprise deployment with the agility of public cloud providers.

2.2 Nutanix Architecture

The Nutanix web-scale converged infrastructure is a scale-out cluster of high-performance nodes (or servers), each running a standard hypervisor and containing processors, memory, and local storage (consisting of SSD Flash and high capacity SATA disk drives). Each node runs virtual machines just like a standard virtual machine host.

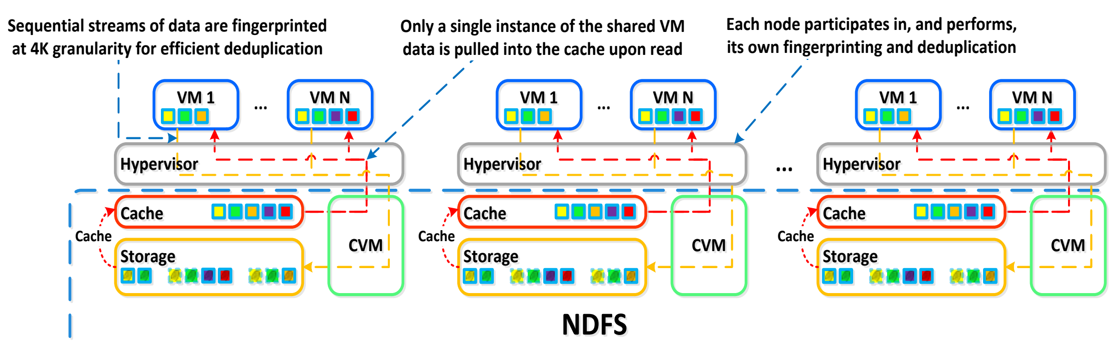


In addition, local storage from all nodes is virtualized into a unified pool by the Nutanix Distributed File System (NDFS). In effect, NDFS acts like an advanced NAS that uses local SSDs and disks from all nodes to store virtual machine data. Virtual machines running on the cluster write data to NDFS as if they were writing to shared storage.

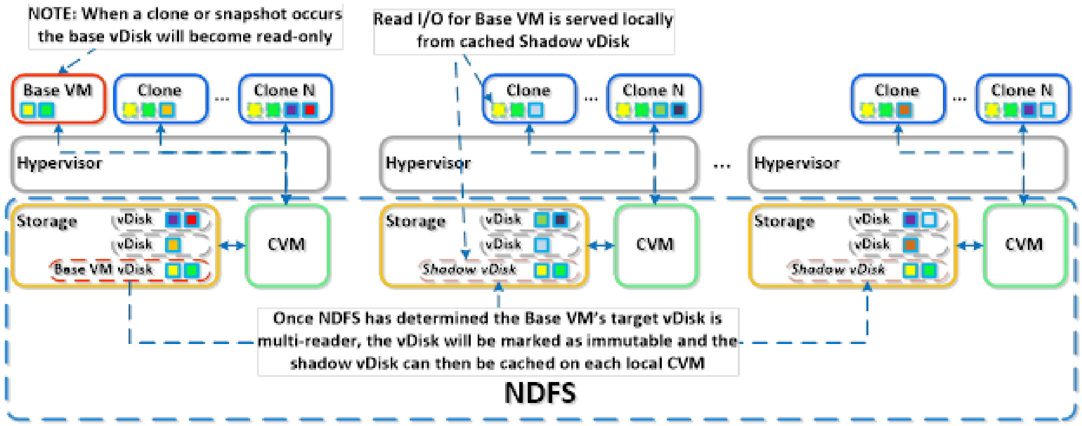


NDFS understand the concept of a virtual machine and provides advanced data management features. It brings data closer to virtual machines by storing the data locally on the system, resulting in higher performance at a lower cost. Nutanix platforms can horizontally scale from as few as three nodes to a large number of nodes, enabling organizations to scale their infrastructure as their needs grow.

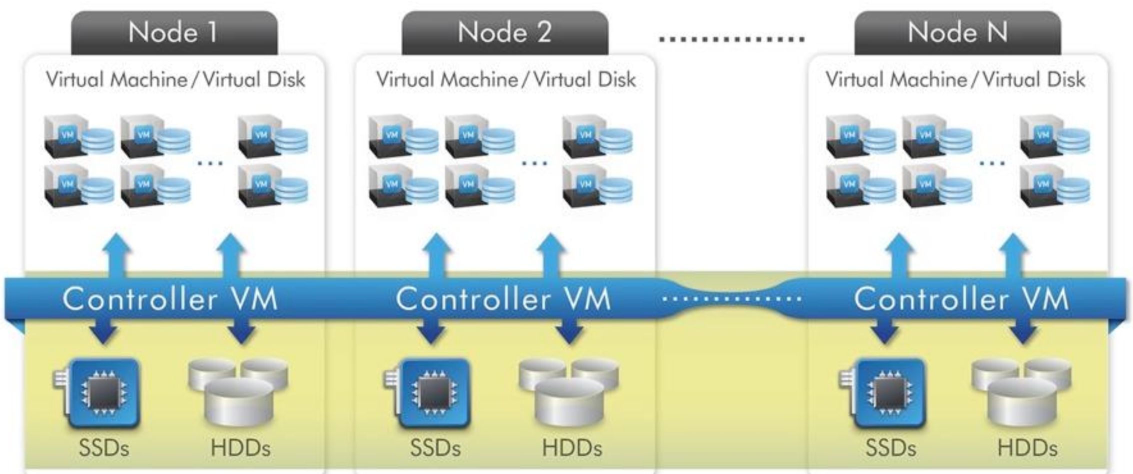
The Nutanix Elastic Deduplication Engine is a software-driven, massively scalable and intelligent data reduction technology. It increases the effective capacity in the disk tier, as well as the RAM and flash cache tiers of the system, by eliminating duplicate data. This substantially increases storage efficiency, while also improving performance due to larger effective cache capacity in RAM and flash. Deduplication is performed by each node individually in the cluster, allowing for efficient and uniform deduplication at scale. This technology is increasingly effective with full/persistent clones or P2V migrations.



Nutanix Shadow Clones delivers distributed localized caching of virtual disks performance in multi-reader scenarios, such as desktop virtualization using VMware Horizon or RDSH. With Shadow Clones, the CVM actively monitors virtual disk access trends. If there are requests originating from more than two remote CVMs, as well as the local CVM, and all of the requests are read I/O and the virtual disk will be marked as immutable. Once the disk has been marked immutable, the virtual disk is then cached locally by each CVM, so read operations are now satisfied locally by local storage.



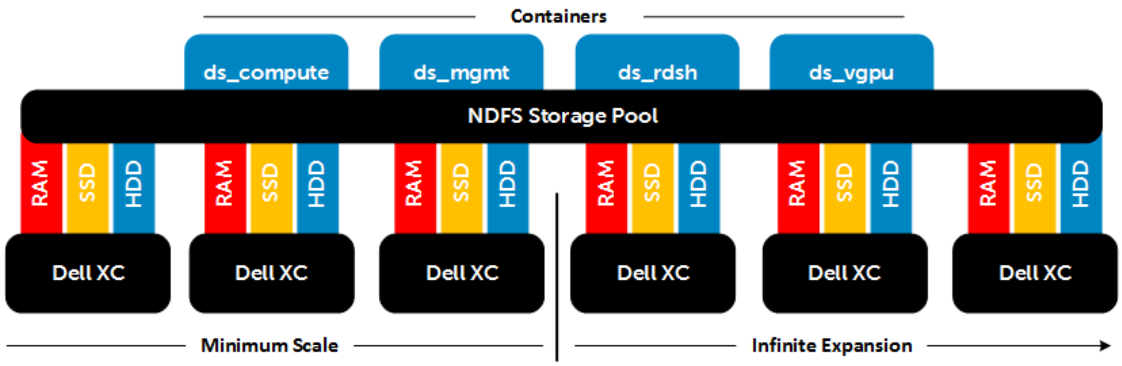
The benefits of the Nutanix Platform are now exposed to scale out vSphere deployments:



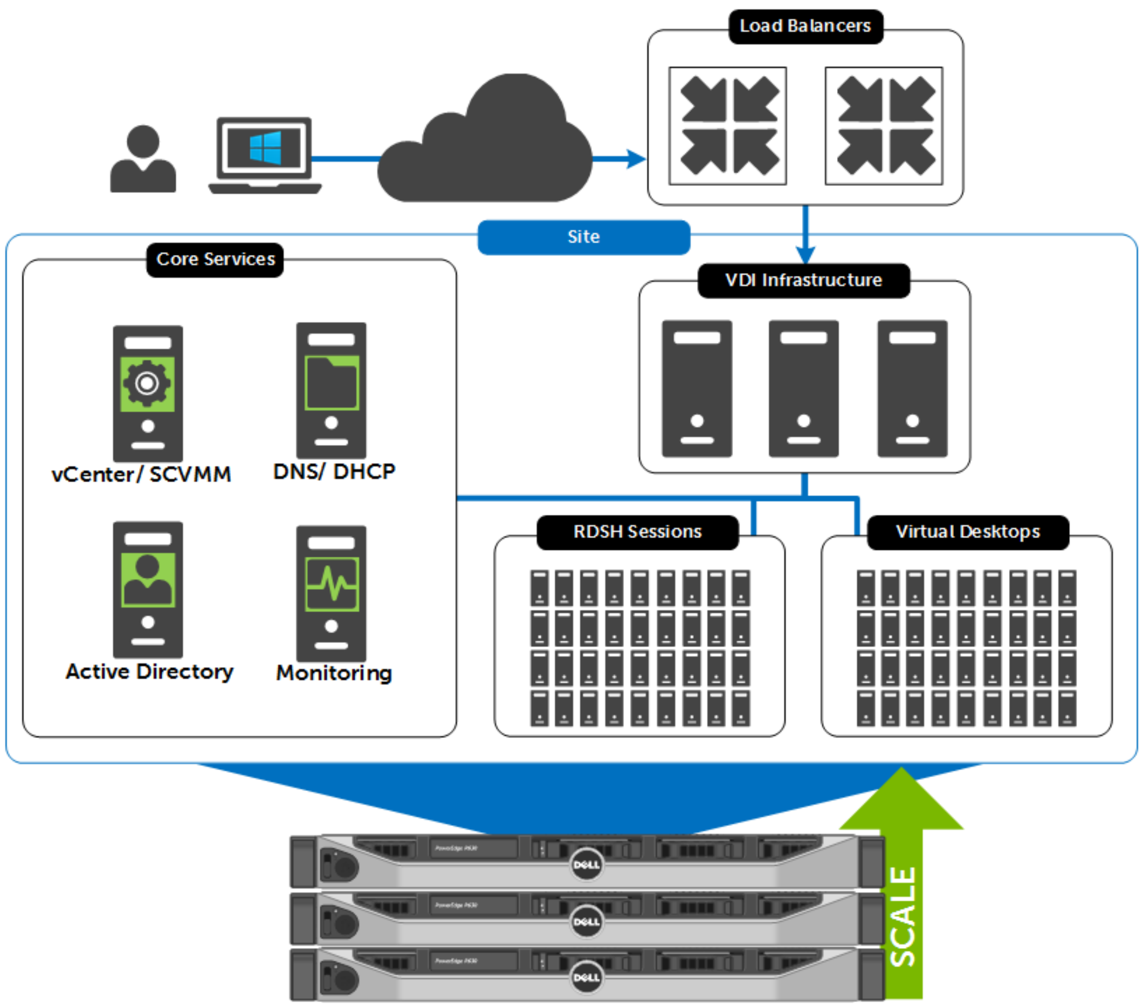
2.3 Nutanix Web-scale Converged Infrastructure

The Nutanix web-scale converged infrastructure provides an ideal combination of both high-performance compute with localized storage to meet any demand. True to this capability, this reference architecture contains zero reconfiguration of or customization to the Nutanix product to optimize for this use case.

The next figure shows a high-level example of the relationship between an XC node, storage pool, container, pod and relative scale out:

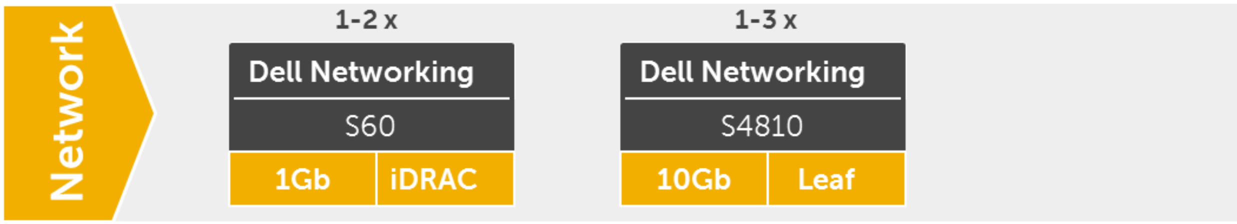


Dell XC Web Scale allows organizations to deliver virtualized or remote desktops and applications through a single platform and support end users with access to all of their desktops and applications in a single place.



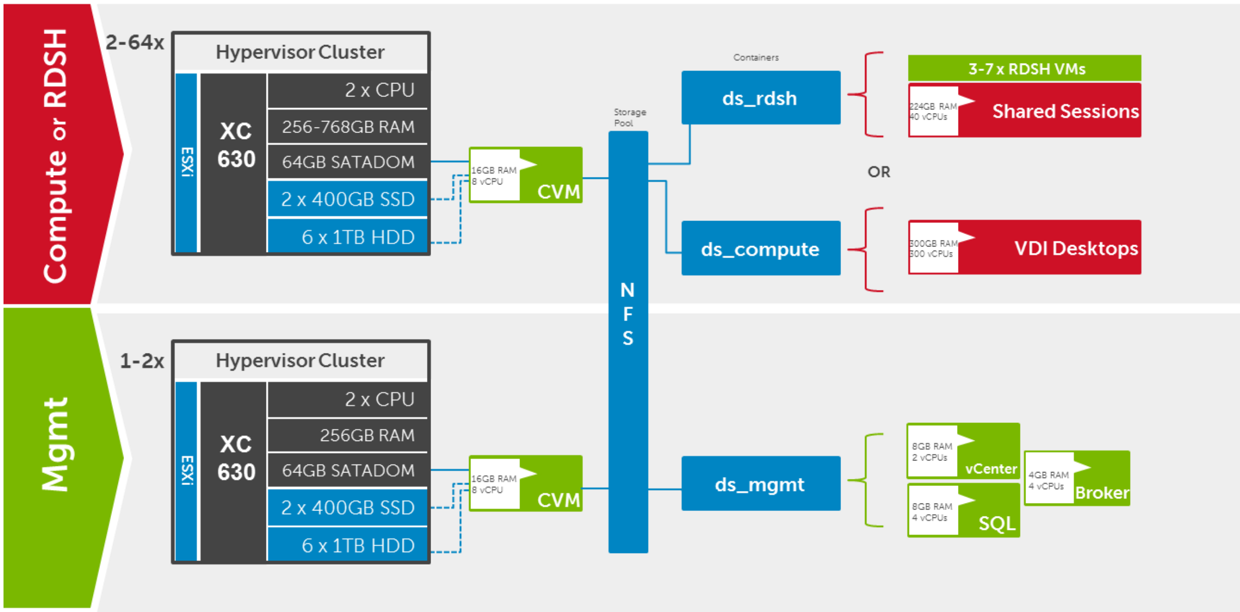
2.4 Dell XC Web Scale – Solution Pods

The networking layer consists of the 10Gb Dell Networking S4810 utilized to build a world-class leaf/spine architecture with robust 1Gb switching in the S60 for iDRAC connectivity.

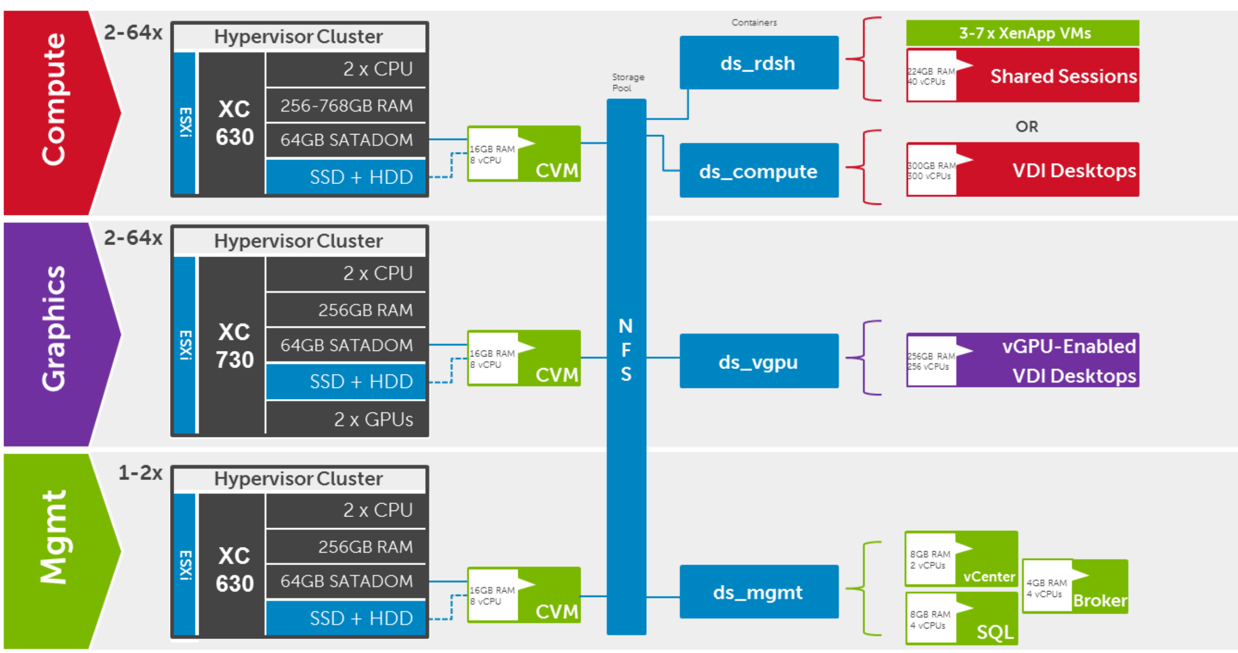


The compute, management and storage layers are converged into a single server XC Series appliance cluster, hosting VMware vSphere. The recommended boundaries of an individual pod are based on number of nodes supported within a given hypervisor cluster, 64 nodes for vSphere 6.

Dell recommends that the VDI management infrastructure nodes be separated from the compute resources onto their own appliance cluster with a common storage namespace shared between them based on NFS for vSphere. One node for VDI management is required, minimally, and expanded based on size of the pod. The designations ds_rdsh, ds_compute, ds_vgpu and ds_mgmt as seen below are logical NDFS containers used to group VMs of a particular type. Using distinct containers allows features and attributes, such as compression and deduplication, to be applied to groups of VMs that share similar characteristics. Compute hosts can be used interchangeably for Horizon or RDSH as required. Distinct clusters should be built for management and compute hosts for HA, respectively, to plan predictable failover, scale and load across the pod. The NFS namespace can be shared across multiple hypervisor clusters adding disk capacity and performance for each distinct cluster.



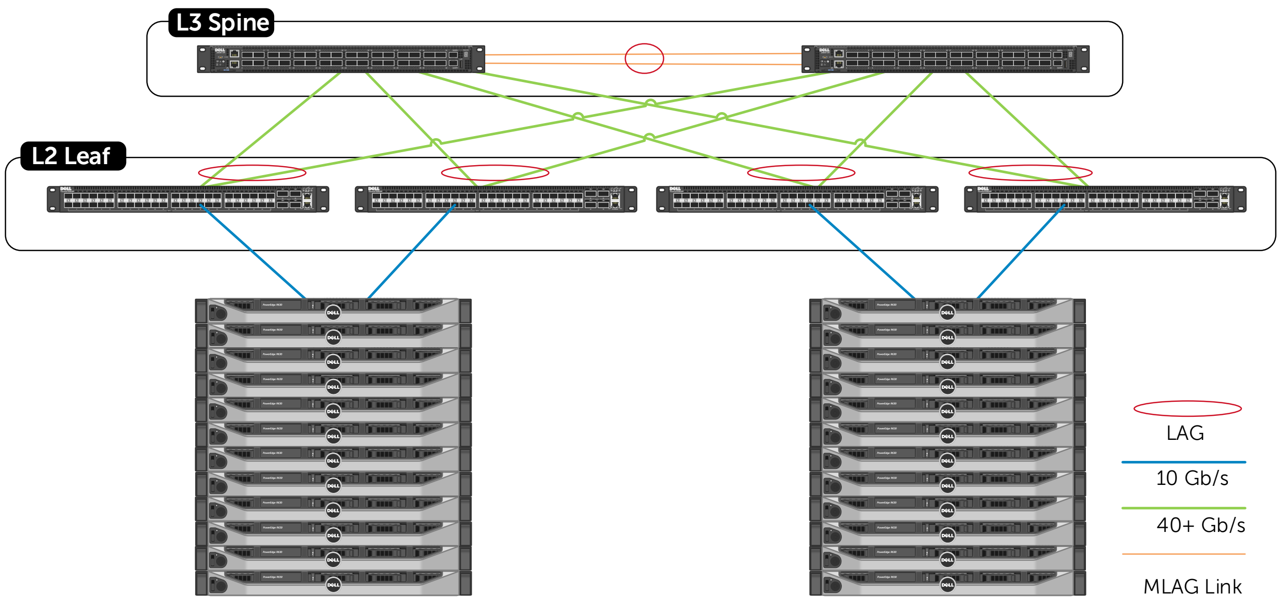
High-performance graphics capabilities compliment the solution and can easily be added at any time to any new or existing Dell XC vSphere deployment. Simply add the appropriate number of XC730 appliances to your NDFS cluster and provide a superior user experience with vSphere 6 and NVIDIA GRID vGPU technology.



2.4.1 Network Architecture

Designed for true linear scaling, Dell XC 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 20Gb active throughput from each node to its Leaf and scalable 80Gb active throughput from each Leaf to Spine switch providing scale from 3 XC nodes to thousands without any impact to available bandwidth:



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 10Gb runs and for longer runs use fiber with SFPs.

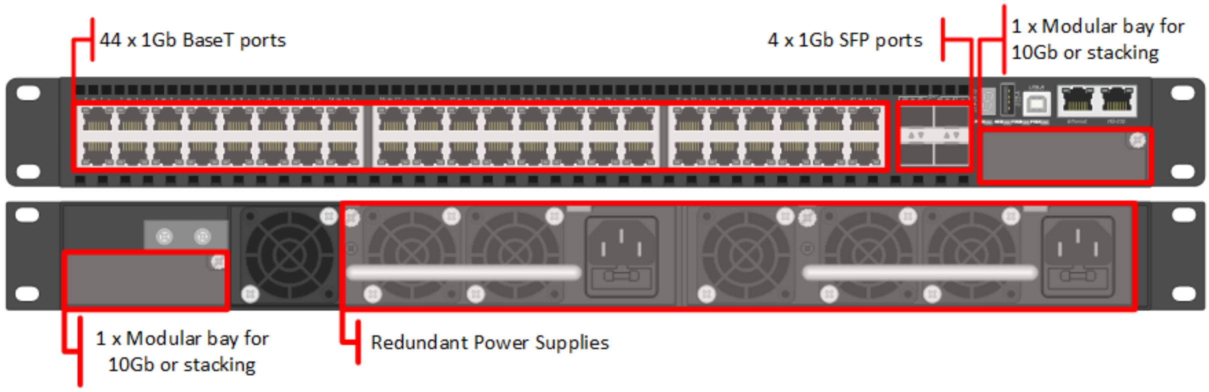
3.1.1 Dell Networking S60 (1Gb ToR Switch)

The Dell Networking S-Series S60 is a high-performance 1/ 10Gb access switch optimized for lowering operational costs at the network edge and is recommended for iDRAC connectivity. The S60 answers the key challenges related to network congestion in data center ToR (Top-of-Rack) and service provider aggregation deployments. As the use of bursty applications and services continue to increase, huge spikes in network traffic that can cause network congestion and packet loss, also become more common. The S60 is equipped with the industry's largest packet buffer (1.25 GB), enabling it to deliver lower application latency and maintain predictable network performance even when faced with significant spikes in network traffic. Providing 48 line-rate Gb ports and up to four optional 10Gb uplinks in just 1-RU, the S60 conserves valuable rack space. Further, the S60 design delivers unmatched configuration flexibility, high reliability, and power and cooling efficiency to reduce costs.

<table>
<tr><th>Model</th><th>Features</th><th>Options</th><th>Uses</th></tr>
<tr><td rowspan="4">Dell Networking S60</td><td rowspan="4">44 x BaseT (10/100/1000) + 4 x SFP

High performance

High Scalability</td><td>Redundant PSUs</td><td rowspan="4">1Gb connectivity for iDRAC</td></tr>
<tr><td>4 x 1Gb SFP ports the support copper or fiber</td></tr>
<tr><td>12Gb or 24Gb stacking (up to 12 switches)</td></tr>
<tr><td>2 x modular slots for 10Gb uplinks or stacking modules</td></tr>
</table>



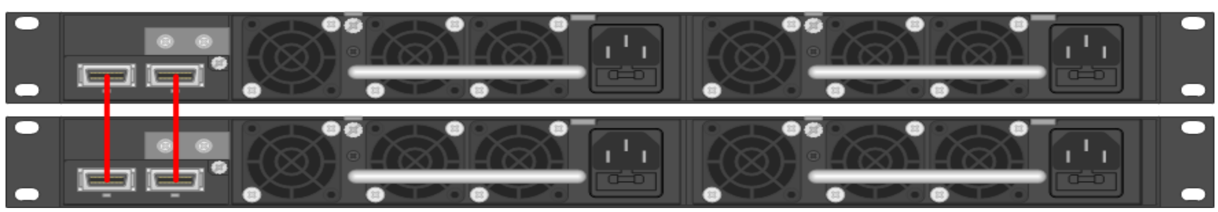
Guidance:

- 10Gb uplinks to a core or distribution switch are the preferred design choice using the rear 10Gb uplink modules. If 10Gb to a core or distribution switch is unavailable the front 4 x 1Gb SFP ports are used.
- The front 4 SFP ports can support copper cabling and are upgraded to optical if a longer run is needed.

For more information on the S60 switch and Dell Networking, please visit: LINK

3.1.1.1 S60 Stacking

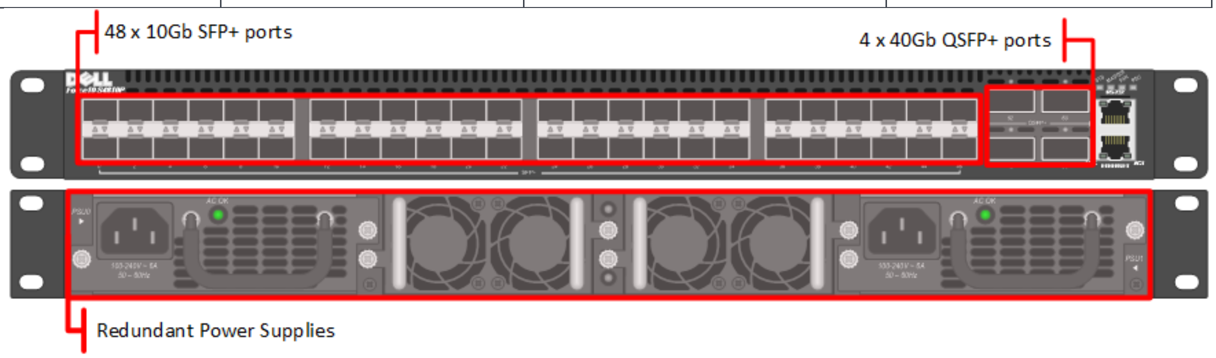
The S60 switches are optionally stacked with 2 or more switches, if greater port count or redundancy is desired. Each switch will need a stacking module plugged into a rear bay and connected with a stacking cable. The best practice for switch stacks greater than 2 is to cable in a ring configuration with the last switch in the stack cabled back to the first. Uplinks need to be configured on all switches in the stack back to the core to provide redundancy and failure protection.



3.1.2 Dell Networking S4810 (10Gb ToR Leaf Switch)

The Dell Networking S-Series S4810 is an ultra-low latency 10/40Gb Top-of-Rack (ToR) switch purpose-built for applications in high-performance data center and computing environments. Leveraging a non-blocking, cut-through switching architecture, the S4810 delivers line-rate L2 and L3 forwarding capacity with ultra-low latency to maximize network performance. The compact S4810 design provides industry-leading density of 48 dual-speed 1/10Gb (SFP+) ports as well as four 40Gb QSFP+ uplinks to conserve valuable rack space and simplify the migration to 40Gb in the data center core (Each 40Gb QSFP+ uplink can support four 10Gb ports with a breakout cable). Priority-based Flow Control (PFC), Data Center Bridge Exchange (DCBX), Enhance Transmission Selection (ETS), coupled with ultra-low latency and line rate throughput, make the S4810 ideally suited for converged leaf/spine environments.

Model	Features	Options	Uses
Dell Networking S4810	48 x SFP+ (1Gb/10Gb) + 4 x QSFP+ (40Gb) Redundant Power Supplies	Single-mode/ multimode optics, TwinAx, QSFP+ breakout cables Stack up to 6 switches or 2 using VLT, using SFP or QSFP ports	ToR switch for 10Gb converged connectivity



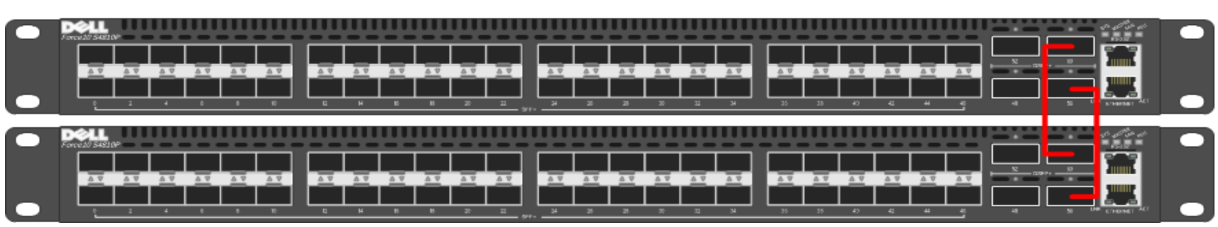
Guidance:

- The 40Gb QSFP+ ports are split into 4 x 10Gb ports using breakout cables for stand-alone units, if necessary. This is not supported in stacked configurations.
- 10Gb or 40Gb uplinks to a core or distribution switch is the preferred design choice.
- The front 4 SFP ports can support copper cabling and are upgraded to optical if a longer run is needed.

For more information on the S4810 switch and Dell Networking, please visit: LINK

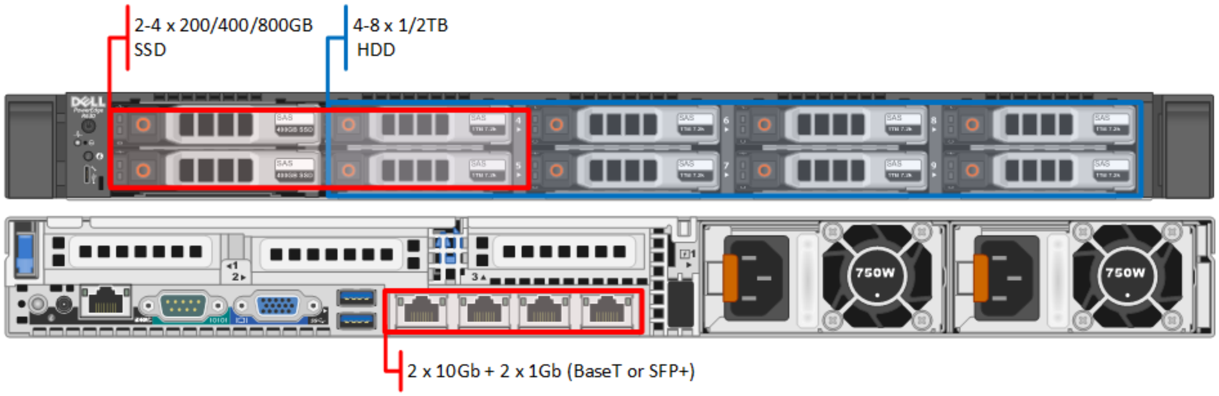
3.1.2.1 S4810 Stacking

The S4810 switches are optionally stacked up to 6 switches or configured to use Virtual Link Trunking (VLT) up to 2 switches. Stacking is supported on either SFP or QSFP ports as long as that port is configured for stacking. The best practice for switch stacks greater than 2 is to cable in a ring configuration with the last switch in the stack cabled back to the first. Uplinks need to be configured on all switches in the stack back to the core to provide redundancy and failure protection. It is recommended that the S4810 be configured for use in the leaf layer connective up to another switch in the spine layer.



3.2 Dell XC Converged Appliance

Consolidate compute and storage into a single chassis with Dell XC Series web-scale converged appliances, powered by Nutanix software. XC Series appliances install quickly, integrate easily into any data center, and can be deployed for multiple virtualized workloads including desktop virtualization, test and development, and private cloud projects. For general purpose virtual desktop and virtual application solutions, Dell recommends the XC630. For more information please visit: Link



While the XC630 is ultimately a flexible and highly configurable converged appliance, Dell offers three optimized platforms with which to build your desktop virtualization project. The A5 configuration is recommended for entry-level, small scale or POC deployments where maximizing a balance of low cost and performance is crucial. The B5 boats a balanced configuration best suited for small or large production deployments consisting of task or knowledge workers. Finally the B7 configuration is positioned as the ultimate in performance and scalability providing an abundance of CPU power and tiered disk capacity to suit a virtual desktop project of any scale or user workload.

	XC630-A5	XC630-B5	XC630-B7
	Low core CPUs (8C)	Mid core CPUs (12C)	High core CPUs (16C)
	Low density RAM	Medium density RAM	Medium density RAM
	Two tiers: Low Capacity SSD + HDD	Two tiers: Medium Capacity SSD + Low Capacity HDD	Two tiers: Medium Capacity SSD + High Capacity HDD
	Non-persistent VDI + RDSH	Non-persistent VDI + RDSH	Persistent or Non-persistent VDI + RDSH
	XC630 (10 x 2.5")	**XC630 (10 x 2.5")**	**XC630 (10 x 2.5")**
CPU	2 x E5-2630v3 (8C, 2.4GHz)	2 x E5-2680v3 (12C, 2.5GHz)	2 x E5-2698v3 (16C, 2.3GHz)
Memory	16 x 16GB 2133MHz RDIMMs **Effective speed: 2133MHz @ 256GB**	24 x 16GB 2133MHz RDIMMs **Effective speed: 1866MHz @ 384GB**	24 x 16GB 2133MHz RDIMMs **Effective speed: 1866MHz @ 384GB**
RAID Ctrls	PERC H730 Mini – no RAID	PERC H730 Mini – no RAID	PERC H730 Mini – no RAID
Storage	64GB SATADOM **(CVM/ Hypervisor)** 2 x 200GB MLC SSD 2.5" (T1) 4 x 1TB HDD 2.5" (T2)	64GB SATADOM **(CVM/ Hypervisor)** 2 x 400GB MLC SSD 2.5" (T1) 4 x 1TB HDD 2.5" (T2)	64GB SATADOM **(CVM/ Hypervisor)** 2 x 400GB MLC SSD 2.5" (T1) 6 x 1TB HDD 2.5" (T2)
Network	2 x 10Gb, 2 x 1Gb SFP+/ BT	2 x 10Gb, 2 x 1Gb SFP+/ BT	2 x 10Gb, 2 x 1Gb SFP+/ BT
iDRAC	iDRAC8 Ent w/ vFlash, 8GB SD	iDRAC8 Ent w/ vFlash, 8GB SD	iDRAC8 Ent w/ vFlash, 8GB SD
Power	2 x 750W PSUs	2 x 750W PSUs	2 x 750W PSUs

3.2.1 Dell XC630 (A5)

The Dell XC630-A5 platform is perfect for POCs, lighter user workloads, shared sessions or application virtualization. Each appliance comes equipped with dual 8-core CPUs and 256GB of high-performance RAM. Six disks come in each host, 2 x 200GB SSD for the hot tier (Tier1) and 4 x 1TB NL SAS disks for the cold tier (Tier2). The 64GB SATADOM boots the hypervisor and Nutanix Controller VM while the H730 PERC is configured in pass-through mode connecting to the SSDs and HDDs. 64GB is consumed on each of the first two SSDs for the Nutanix "home". These six disks are presented to the Nutanix Controller VM running locally on each host. Each platform can be outfitted with SFP+ or BaseT NICs.

Dell XC630 – A5	
CPU	2 x E5-2630v3 (8C, 2.4GHz)
Memory	16 x 16GB 2133MHz RDIMMs Effective speed: 2133MHz @ 256GB
RAID Ctrls	PERC H730 Mini – no RAID
Storage	64GB SATADOM **(CVM/ Hypervisor)** 2 x 200GB MLC SATA SSD 2.5" (T1) 4 x 1TB NL SAS 2.5" (T2)
Network	2 x 10Gb, 2 x 1Gb SFP+/ BT
iDRAC	iDRAC8 Ent w/ vFlash, 8GB SD
Power	2 x 750W PSUs

3.2.2 Dell XC630 (B5)

The Dell XC630-B5 platform is perfect for larger POCs, medium user workloads, shared sessions or application virtualization. Each appliance comes equipped with dual 12-core CPUs and 384GB of high-performance RAM. Six disks come in each host, 2 x 400GB SSD for the hot tier (Tier1) and 4 x 1TB NL SAS disks for the cold tier (Tier2). The 64GB SATADOM boots the hypervisor and Nutanix Controller VM while the H730 PERC is configured in pass-through mode connecting to the SSDs and HDDs. 64GB is consumed on each of the first two SSDs for the Nutanix "home". These six disks are presented to the Nutanix Controller VM running locally on each host. Each platform can be outfitted with SFP+ or BaseT NICs.

Dell XC630 – B5	
CPU	2 x E5-2680v3 (12C, 2.5GHz)
Memory	24 x 16GB 2133MHz RDIMMs Effective speed: 1866 MHz @ 384GB
RAID Ctrls	PERC H730 Mini – no RAID
Storage	64GB SATADOM **(CVM/ Hypervisor)** 2 x 400GB MLC SATA SSD 2.5" (T1) 4 x 1TB NL SAS 2.5" (T2)
Network	2 x 10Gb, 2 x 1Gb SFP+/ BT
iDRAC	iDRAC8 Ent w/ vFlash, 8GB SD
Power	2 x 750W PSUs

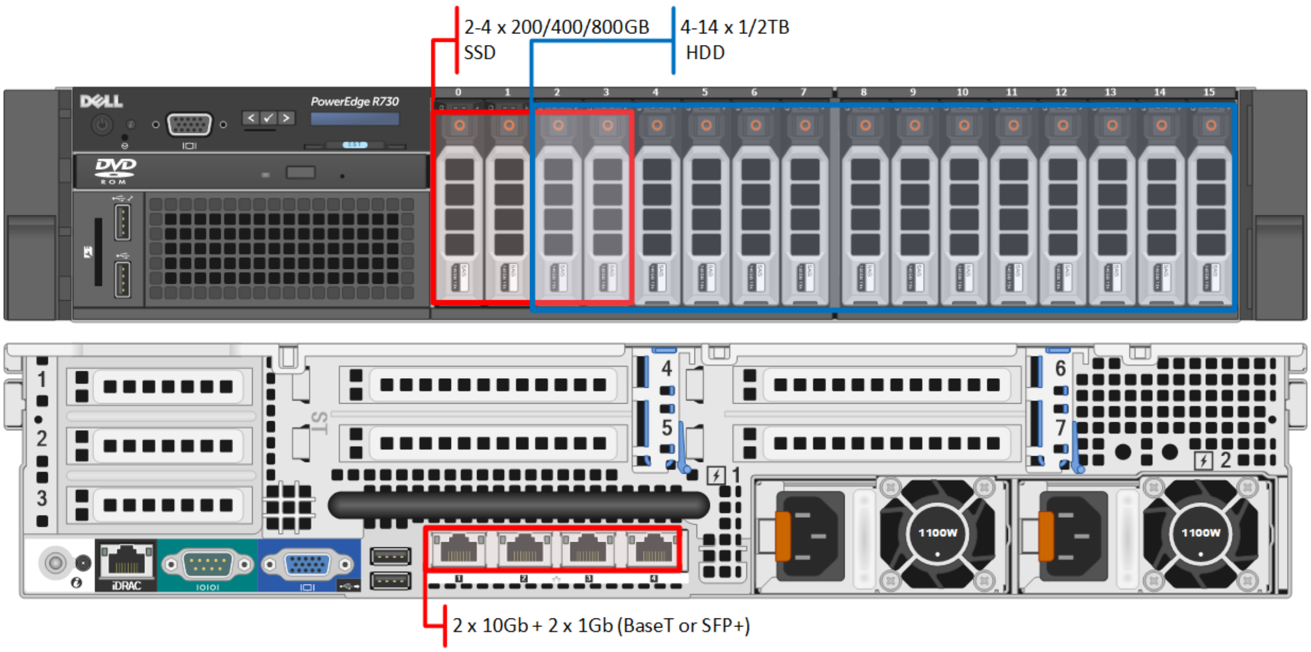
3.2.3 Dell XC630 (B7)

The Dell XC630-B7 platform is ideal for high performance requirements, heavy user workloads, and dense shared sessions or application virtualization. Each appliance comes equipped with dual 16-core CPUs and 384GB of high-performance RAM. Six disks come in each host, 2 x 400GB SSD for the hot tier (Tier1) and 6 x 1TB NL SAS disks for the cold tier (Tier2). The 64GB SATADOM boots the hypervisor and Nutanix Controller VM while the H730 PERC is configured in pass-through mode connecting to the SSDs and HDDs. 64GB is consumed on each of the first two SSDs for the Nutanix "home". These eight disks are presented to the Nutanix Controller VM running locally on each host. Each platform can be outfitted with SFP+ or BaseT NICs.

Dell XC630 – B7	
CPU	2 x E5-2698v3 (16C, 2.3GHz)
Memory	24 x 16GB 2133MHz RDIMMs Effective speed: 1866 MHz @ 384GB
RAID Ctrls	PERC H730 Mini – no RAID
Storage	64GB SATADOM **(CVM/ Hypervisor)** 2 x 400GB MLC SATA SSD 2.5" (T1) 6 x 1TB NL SAS 2.5" (T2)
Network	2 x 10Gb, 2 x 1Gb SFP+/ BT
iDRAC	iDRAC8 Ent w/ vFlash, 8GB SD
Power	2 x 750W PSUs

3.2.4 Dell XC730 (Graphics)

The Dell-optimized XC730 platform is ideal for high performance graphics workloads. Each appliance comes equipped with dual 14-core 120w CPUs and 256GB of high-performance RAM supporting up to 64 users per XC730. Six disks come standard in each host, 2 x 400GB SSD for the hot tier (Tier1) and 4 x 1TB NL SAS disks for the cold tier (Tier2). The 64GB SATADOM boots the hypervisor and Nutanix Controller VM while the H730 PERC is configured in pass-through mode connecting to the SSDs and HDDs. 64GB is consumed on each of the first two SSDs for the Nutanix "home". These six disks are presented to the Nutanix Controller VM running locally on each host. Each platform can be outfitted with SFP+ or BaseT NICs.



Important to note that this platform must be configured using CPUs with a max TDP of 120w and requires 1100w PSUs.

Dell XC730 – Graphics	
CPU	2 x E5-2695v3 (14C, 2.3GHz)
Memory	16 x 16GB 2133MHz RDIMMs Effective speed: 2133 MHz @ 256GB
GPU	2 x NVIDIA Grid K2; vGPU Profile: K220Q
RAID Ctrls	PERC H730 Mini – no RAID
Storage	64GB SATADOM **(CVM/ Hypervisor)** 2 x 400GB MLC SATA SSD 2.5" (T1); 4 x 1TB NL SAS 2.5" (T2)
Network	2 x 10Gb, 2 x 1Gb SFP+/ BT
iDRAC	iDRAC8 Ent w/ vFlash, 8GB SD
Power	2 x 1100W PSUs

3.3 GPUs

3.3.1 NVIDIA GRID K1 and K2

NVIDIA GRID™ technology offers the ability to offload graphics processing from the CPU to the GPU in virtualized environments, allowing the data center manager to deliver true PC graphics-rich experiences to more users for the first time. NVIDIA's Kepler™-based GRID K1 and K2 boards are specifically designed to enable rich graphics in virtualized environments.

GPU Virtualization

GRID boards allow hardware virtualization of the GPU. This means multiple users can share a single GPU, improving user density while providing true PC performance and compatibility.

Low-Latency Remote Display

NVIDIA's patented low-latency remote display technology greatly improves the user experience by reducing the lag that users feel when interacting with their virtual machine. With this technology, the virtual desktop screen is pushed directly to the remoting protocol.

Maximum User Density

NVIDIA GRID boards have an optimized multi-GPU design that helps to maximize user density. GRID K1 boards, which include four Kepler-based GPUs and 16GB of memory, are designed to host the maximum number of concurrent users. GRID K2 boards, which include two higher end Kepler GPUs and 8GB of memory, deliver maximum density for users of graphics-intensive applications.

Specs	Grid K1	Grid K2
Number of GPUs	4 x Kepler GPUs (GK107)	2 x high-end Kepler GPUs (GK104)
Total CUDA cores	768 (192 per GPU)	3072 (1536 per GPU)
Core Clock	850 MHz	745 MHz
Total memory size	16 GB DDR3	8 GB GDDR5
Max power	130 W	225 W
Form Factors	Dual slot (4.4" x 10.5")	Dual slot (4.4" x 10.5")
Aux power	6-pin connector	8-pin connector
PCIe	x16 (Gen3)	x16 (Gen3)
Cooling solution	Passive	Passive/ Active

For more information on NVIDIA Grid, please visit: Link

3.4 Dell Wyse Cloud Clients

vmware READY

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

3.4.1 Dell Wyse 5030 PCoIP Zero Client

Uncompromising computing with the benefits of secure, centralized management. The Dell Wyse P25 PCoIP zero client for VMware View is a secure, easily managed zero client that provides outstanding graphics performance for advanced applications such as CAD, 3D solids modeling, video editing and advanced worker-level office productivity applications. Smaller than a typical notebook, this dedicated zero client is designed specifically for VMware View. It features the latest processor technology from Teradici to process the PCoIP protocol in silicon and includes client-side content caching to deliver the highest level of performance available over 2 HD displays in an extremely compact, energy-efficient form factor. The Dell Wyse P25 delivers a rich user experience while resolving the challenges of provisioning, managing, maintaining and securing enterprise desktops. For more information, please visit: Link

3.4.2 Wyse 5010 Thin Client

The Dell Wyse 5010 thin client is a high-performance and secure ThinOS 8 thin client that is absolutely

virus and malware immune. Combining the performance of a dual core AMD G-Series APU with an integrated graphics engine and ThinOS, the D10DP offers exceptional thin client PCoIP processing performance for VMware Horizon View environments that handles demanding multimedia apps with ease and delivers brilliant graphics. Powerful, compact and extremely energy efficient, the D10DP is a great VDI end point for organizations that need high-end performance but face potential budget limitations. For more information, please visit: Link

3.4.3 Dell Wyse 7030 PCoIP Zero Client

Uncompromising computing with the benefits of secure, centralized management. The Dell Wyse 7030 PCoIP zero client for VMware View is a secure, easily managed zero client that provides outstanding graphics performance for advanced applications such as CAD, 3D solids modeling, video editing and advanced worker-level office productivity applications. About the size of a notebook, this dedicated zero client designed specifically for VMware View. It features the latest processor technology from Teradici to process the PCoIP protocol in silicon and includes client-side content caching to deliver the highest level of display performance available over 4 HD displays in a compact, energy-efficient form factor. The Dell Wyse P45 delivers a rich user experience while resolving the challenges of provisioning, managing, maintaining and securing enterprise desktops. For more information, please visit: Link

3.4.4 Wyse 7010 thin client with Linux

Designed for power users, the Dell Wyse 7010 is the highest performing thin client on the market. Highly secure and ultra-powerful, it combines Dell Wyse-enhanced SUSE Linux Enterprise with dual-core AMD 1.65 GHz processor and a revolutionary unified engine for an unprecedented user experience. The Z50D eliminates performance constraints for high-end, processing-intensive applications like computer-aided design, multimedia, D video and 3D modelling. For more information please visit: Link

3.4.5 Wyse 7010 thin client with WES7

This is super high performance Windows Embedded Standard 7 thin client for virtual desktop environments. Featuring a dual core AMD processor and a revolutionary unified engine that eliminates performance constraints, the Z90D7 achieves incredible speed and power for the most demanding embedded windows applications, rich graphics and HD video. With touch screen capable displays, the Z90D7 adds the ease of an intuitive multi touch user experience and is an ideal thin client for the most demanding virtual desktop workload applications. For more information, please visit: Link

3.4.6 Dell Wyse Cloud Connect

Designed to promote bring-your-own-device (BYOD) environments, Dell Wyse Cloud Connect allows you to securely access and share work and personal files, presentations, applications and other content from your business or your home. Managed through Dell Wyse Cloud Client Manager software-as-a-service (SaaS), IT managers can ensure that each Cloud Connect device is used by the appropriate person with the right permissions and access to the appropriate apps and content based on role, department and location. Slightly larger than a USB memory stick, Cloud Connect is an ultra-compact multimedia-capable device. Simply plug it into any available Mobile High-Definition Link (MHL) / HDMI port on a TV or monitor, attach a Bluetooth keyboard and mouse, and you're off and running. Easy to slip into your pocket or bag, it enables an HD-quality window to the cloud, great for meetings and presentations while on business travel, or for cruising the internet and checking email after a day of work. For more information, please visit: Link

3.4.7 Dell Venue 11 Pro

Meet the ultimate in productivity, connectivity and collaboration. Enjoy full laptop performance in an ultra-portable tablet that has unmatched flexibility for a business in motion. This dual purpose device works as a tablet when you're out in the field but also enables you to work on your desktop in the office thanks to an optional dock. For more information, please visit: Link

3.4.8 Dell Chromebook 11

The lightweight, easy-to-use Dell Chromebook 11 helps turn education into exploration - without the worries of safety or security. Priced to make 1:1 computing affordable today, Chromebook 11 is backed by Dell support services to make the most of your budget for years to come. The Chrome OS and Chrome browser get students online in an instant and loads web pages in seconds. A high-density battery supported by a 4th Gen Intel® processor provides up to 10 hours of power. Encourage creativity with the Chromebook 11 and its multimedia features that include an 11.6" screen, stereo sound and webcam.

4 Software Components

4.1 VMware

4.1.1 VMware Horizon

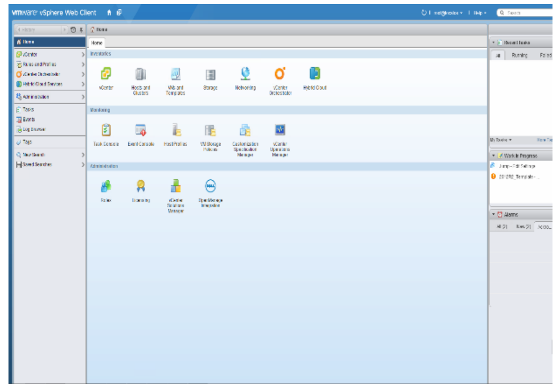
The solution is based on VMware Horizon View which provides a complete end-to-end solution delivering Microsoft Windows virtual desktops to users on a wide variety of endpoint devices. Virtual desktops are dynamically assembled on demand, providing users with pristine, yet personalized, desktops each time they log on.

VMware Horizon View 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. For the complete set of details, please see the Horizon View resources page at http://www.vmware.com/products/horizon-view/resources.html

The core Horizon View components include:

- **View Connection Server (VCS) –** Installed on servers in the data center and brokers client connections, The VCS authenticates users, entitles users by mapping them to desktops and/or pools, establishes secure connections from clients to desktops, support single sign-on, sets and applies policies, acts as a DMZ security server for outside corporate firewall connections and more.
- **View Client –** Installed on endpoints. Is software for creating connections to View desktops that can be run from tablets, Windows, Linux, or Mac PCs or laptops, thin clients and other devices.
- **View Portal –** A web portal to access links for downloading full View clients. With HTML Access Feature enabled enablement for running a View desktop inside a supported browser is enabled.
- **View Agent –** Installed on all VMs, physical machines and Terminal Service servers that are used as a source for View desktops. On VMs the agent is used to communicate with the View client to provide services such as USB redirection, printer support and more.
- **View Administrator –** A web portal that provides admin functions such as deploy and management of View desktops and pools, set and control user authentication and more.
- **View Composer –** This software service can be installed standalone or on the vCenter server and provides enablement to deploy and create linked clone desktop pools (also called non-persistent desktops).
- **vCenter Server –** This is a server that provides centralized management and configuration to entire virtual desktop and host infrastructure. It facilitates configuration, provision, management services. It is installed on a Windows Server 2008 host (can be a VM).
- **View Transfer Server –** Manages data transfers between the data center and the View desktops that are checked out on the end users' desktops in offline mode. This Server is required to support desktops that run the View client with Local Mode options. Replications and syncing are the functions it will perform with offline images.

4.1.2 VMware vSphere 6



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 6 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 6 VM used in the solution is a single Windows Server 2012 R2 VM or vCenter 6 virtual appliance, residing on a host in the management Tier. SQL server is a core component of the Windows version of vCenter and is hosted on another VM also residing in the management Tier. It is recommended that all additional Horizon components be installed in a distributed architecture, one role per server VM.

4.2 Microsoft RDSH

The RDSH servers can exist as physical or virtualized instances of Windows Server 2012 R2. A minimum of one (1), up to a maximum of eight (7) virtual servers are installed per physical compute host. Since RDSH instances are easily added to an existing Horizon stack, the only additional components required are:

- One or more Windows Server OS instances added to the Horizon site

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

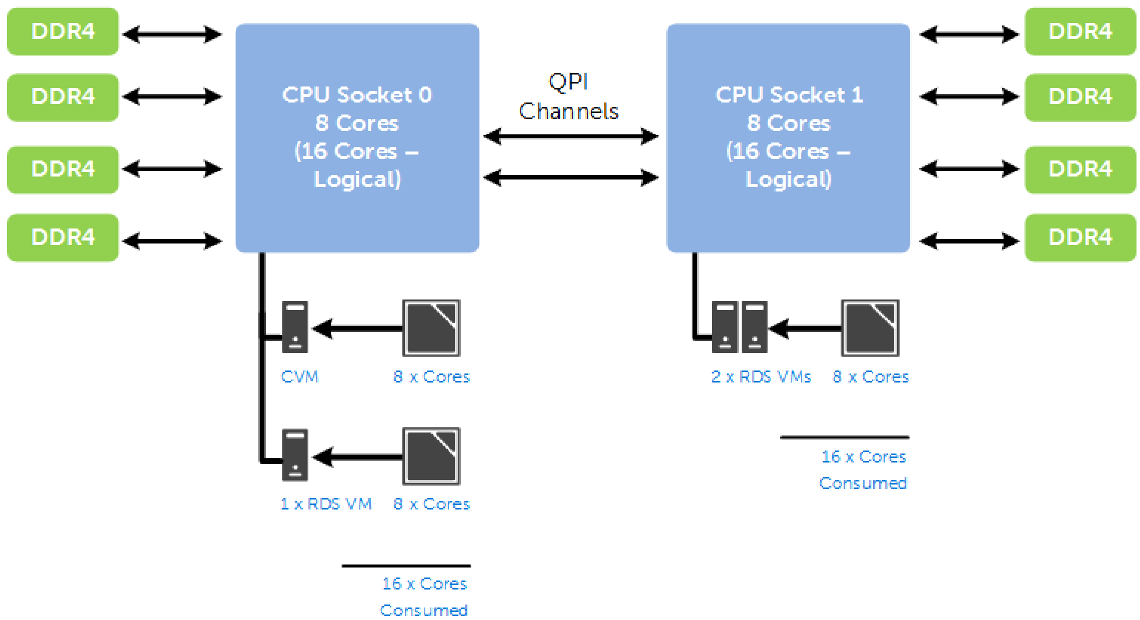
4.2.1.1 NUMA Architecture Considerations

Best practices and testing has showed that aligning RDSH design to the physical Non-Uniform Memory Access (NUMA) architecture of the server CPUs results in increased and optimal performance. NUMA alignment ensures that a CPU can access its own directly-connected RAM banks faster than those banks of the adjacent processor which are accessed via the Quick Path Interconnect (QPI). The same is true of VMs with large vCPU assignments, best performance will be achieved if your VMs receive their vCPU allotment from a single physical NUMA node. Ensuring that your virtual RDSH servers do not span physical NUMA nodes will ensure the greatest possible performance benefit.

The general guidance for RDSH NUMA-alignment on the Dell XC appliance is as follows:

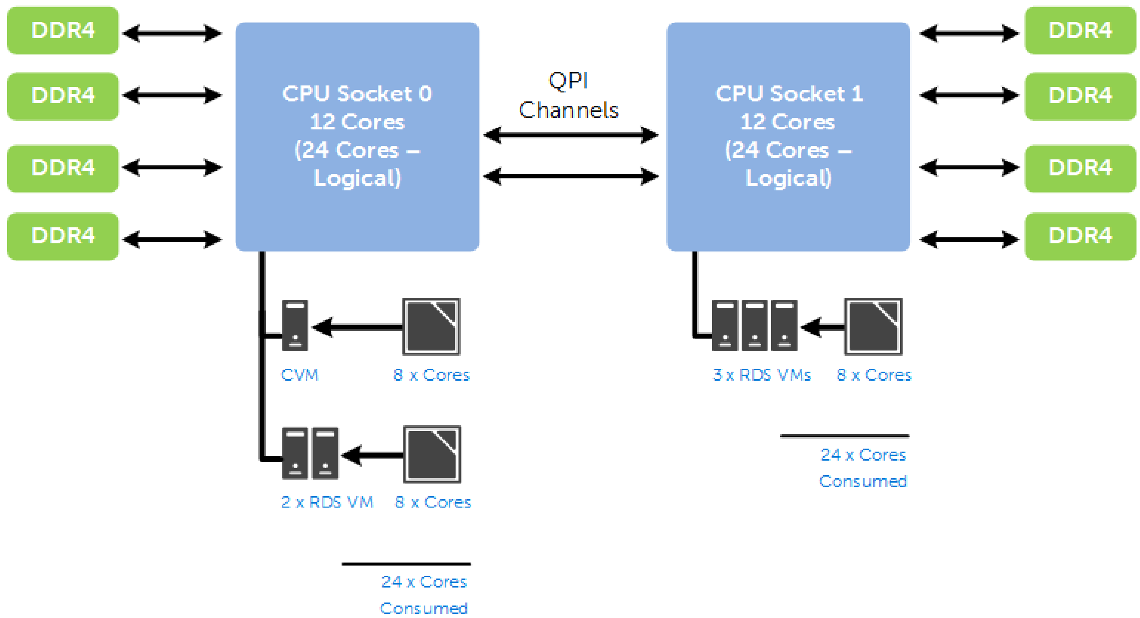
4.2.1.2 A5 NUMA Alignment

8 physical cores per CPU in the A5 platform, 16 logical with Hyperthreading active, gives us a total of 32 consumable cores per appliance and falls in line with a 2x oversubscription rate. The Nutanix CVM will receive its vCPU allotment from the first physical CPU and so configuring the RDSH VMs as shown below will ensure that no NUMA spanning occurs which could lower performance.



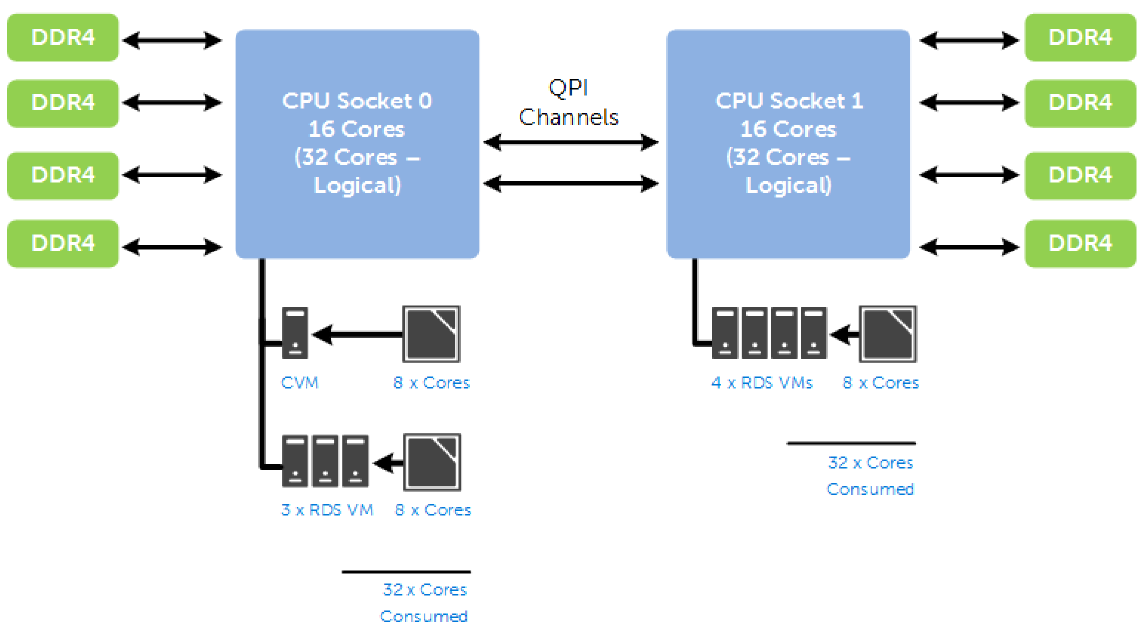
4.2.1.3 B5 NUMA Alignment

12 physical cores per CPU in the A5 platform, 24 logical with Hyper-threading active, gives us a total of 48 consumable cores per appliance and falls in line with a 2x oversubscription rate. The Nutanix CVM will receive its vCPU allotment from the first physical CPU and so configuring the RDSH VMs as shown below will ensure that no NUMA spanning occurs which could lower performance.



4.2.1.4 B7 NUMA Alignment

16 physical cores per CPU in the A5 platform, 32 logical with Hyper-threading active, gives us a total of 64 consumable cores per appliance and falls in line with a 2x oversubscription rate. The Nutanix CVM will receive its vCPU allotment from the first physical CPU and so configuring the RDSH VMs as shown below will ensure that no NUMA spanning occurs which could lower performance.

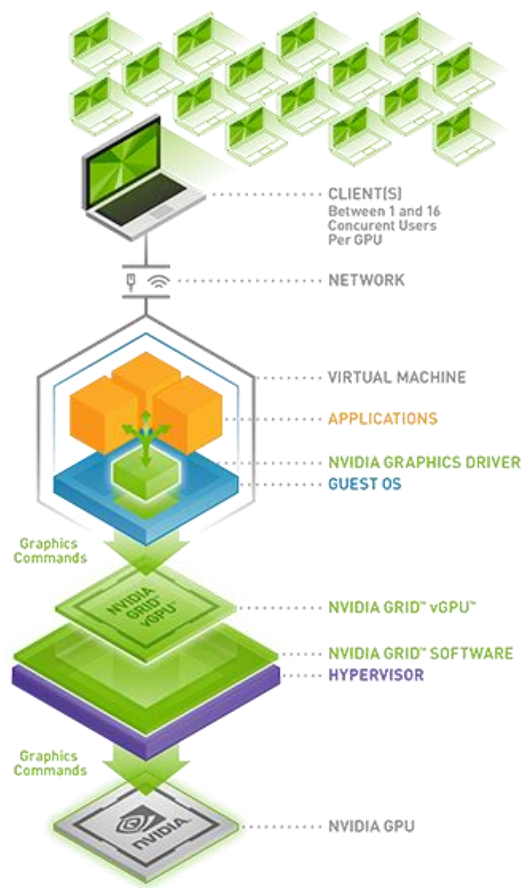


4.3 NVIDIA GRID vGPU

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.



4.3.1 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 Dell graphics server platform is the award winning PowerEdge R730 which can accommodate two NVIDIA K1 or K2 graphics cards. The combination of Dell servers, NVIDIA 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.

Card	vGPU Profile	Graphics Memory	Virtual Display Heads	Maximum Resolution	Physical GPUs	Maximum vGPUs		Intended User(s)
						Per GPU	Per Card	
GRID K2	K280Q	4GB	4	2560x1600	2	1	2	Designer
	K260Q	2GB	4	2560x1600		2	4	Designer
	K240Q	1GB	2	2560x1600		4	8	Power User
	K220Q	512MB	2	2560x1600		8	16	Power User
GRID K1	K180Q	4GB	4	2560x1600	4	1	4	Entry Designer
	K160Q	2GB	4	2560x1600		2	8	Power User
	K140Q	1GB	2	2560x1600		4	16	Power User
	K120Q	512MB	2	2560x1600		8	32	Power User

For more information about NVIDIA GRID vGPU, please visit: LINK

5 Solution Architecture for Horizon

5.1 Management Role Configuration

The Management role recommendations for the base solution are summarized below. Use data disks for role-specific application files such as data, logs and IIS web files in the Management volume.

5.1.1 VMware Horizon Management Role Requirements

Role	vCPU	vRAM (GB)	NIC	OS vDisk	
				Size (GB)	**Location**
Nutanix CVM	8*	16	2	-	C:\ (SATADOM)
Connection Server	4	8	1	40	SDS: ds_mgmt
Primary SQL	4	8	1	40 + 200	SDS: ds_mgmt
vCenter Appliance	2	8	1	125	SDS: ds_mgmt
Total	**18 vCPUs**	**40GB**	**5 vNICs**	**405GB**	**-**

5.1.2 RDSH on vSphere

The recommended number of RDSH VMs and their configurations on vSphere are summarized below based on applicable hardware platform.

Role	HW Config	VMs per host	vCPUs per VM	RAM (GB)	NIC	OS vDisk	
						Size (GB)	Location
RDSH VM	A5	3	8	32	1	80	SDS: ds_rdsh
RDSH VM	B5	5	8	32	1	80	SDS: ds_rdsh
RDSH VM	B7	7	8	32	1	80	SDS: ds_rdsh

5.1.3 SQL Databases

The VMware databases are hosted by a single dedicated SQL Server 2012 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 all Databases that are required for:

- VMware Horizon
- vCenter (if using Windows version)

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 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 is used to control access to the various VMware and Microsoft 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, Horizon 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 XC Web Scale appliances come with two tiers of storage by default, SSD for performance and HDD for capacity. A single common Software Defined Storage namespace is created across the Nutanix cluster and presented as NFS to the hypervisor of each host. This constitutes a storage pool and one should be sufficient per cluster. Within this common namespace, logical containers are created to group VM files as well as control the specific storage-related features that are desired to be enabled such as deduplication and compression.

5.2.1 Nutanix Containers

The following table outlines the recommended containers, their purpose and settings given the use case. Best practices suggest using as few features as possible, only enable what is absolutely required. For example, if you are not experiencing disk capacity pressure then there is no need to enable Capacity Tier Deduplication. Enabling unnecessary services increases the resource demands of the Controller VMs. Capacity tier deduplication requires that CVMs be configured with 32GB RAM.

Container	Purpose	Replication Factor	Perf Tier Deduplication	Capacity Tier Deduplication	Compression
Ds_compute	Desktop VMs	2	Enabled	Disabled	Disabled
Ds_mgmt	Mgmt Infra VMs	2	Enabled	Disabled	Disabled
Ds_rdsh	RDSH Server VMs	2	Enabled	Disabled	Disabled
Ds_vgpu	vGPU-enabled VMs	2	Enabled	Disabled	Disabled

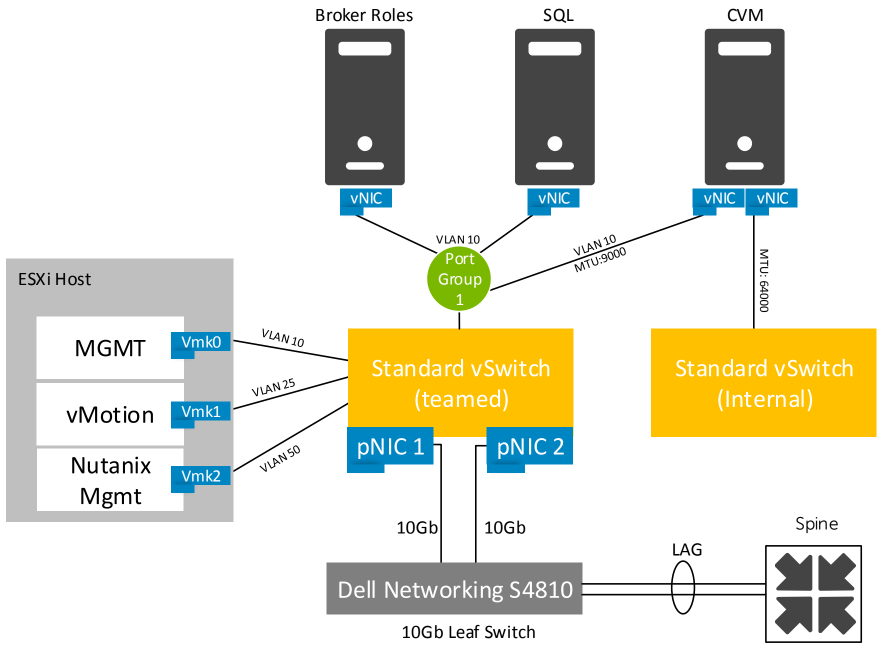
5.3 Virtual Networking

The network configuration for the Dell XC Web Scale appliances utilizes a 10Gb converged infrastructure model. All required VLANs will traverse 2 x 10Gb 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:

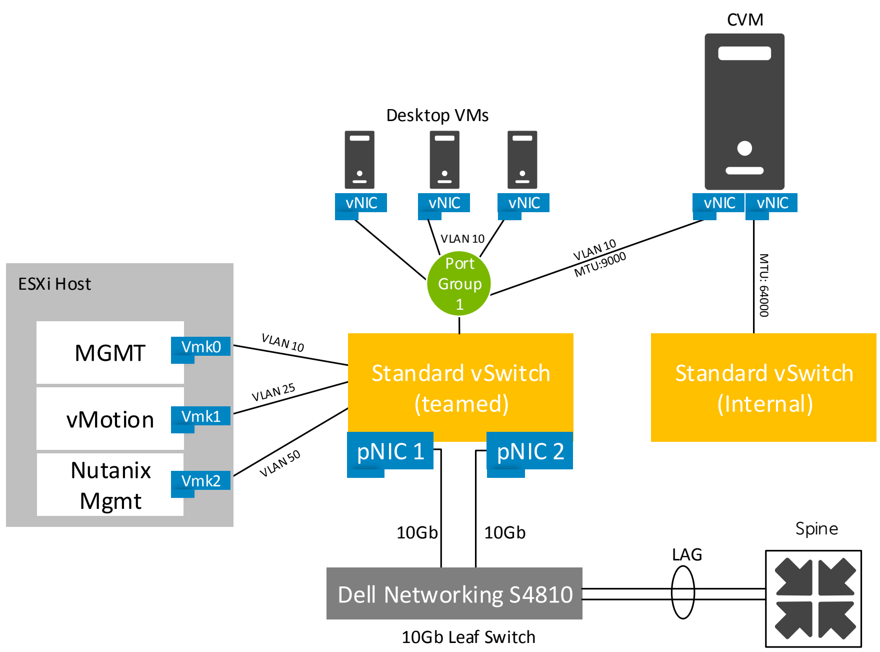
- Compute hosts
    - Management VLAN: Configured for hypervisor infrastructure traffic – L3 routed via spine layer
    - vMotion VLAN: Configured for vMotion traffic – L2 switched via leaf layer
    - VDI VLAN: Configured for VDI session traffic – L3 routed via spine layer
- Management hosts
    - Management VLAN: Configured for hypervisor Management traffic – L3 routed via spine layer
    - vMotion VLAN: Configured for vMotion traffic – L2 switched via leaf layer
    - VDI Management VLAN: Configured for VDI infrastructure traffic – L3 routed via spine layer
- An iDRAC VLAN is configured for all hardware management traffic – L3 routed via spine layer

5.3.1 vSphere

The Management host network configuration consists of a standard vSwitch teamed with 2 x 10Gb physical adapters assigned. The CVM connects to a private internal vSwitch as well as the standard external vSwitch. All VMkernel service ports connect to the standard external vSwitch. All VDI infrastructure VMs connect through the primary port group on the external vSwitch.

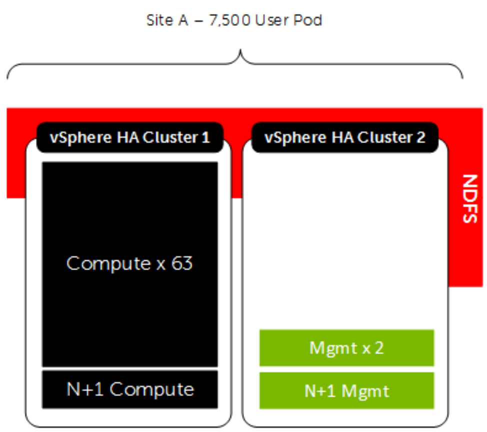


The Compute hosts are configured in the same basic manner with the desktop VMs connecting to the primary port group on the external vSwitch.

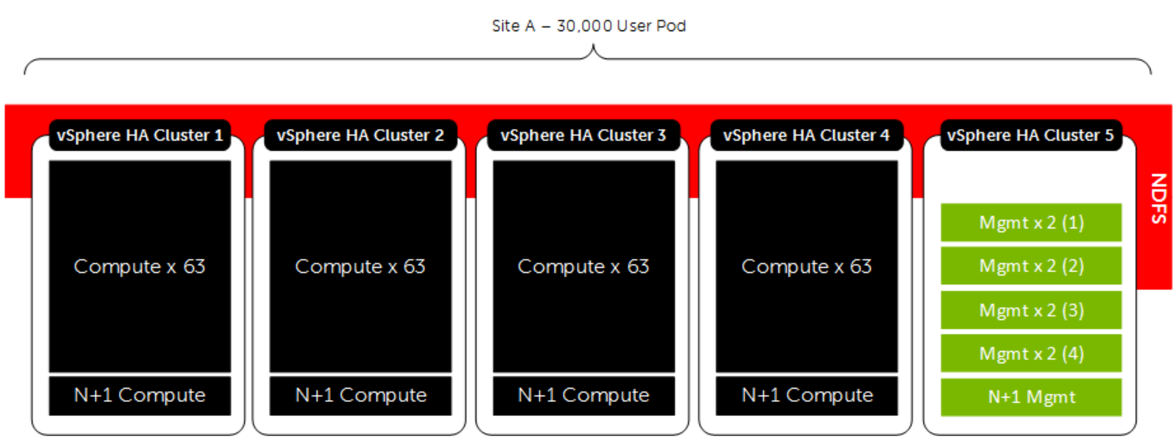


5.4 Scaling Guidance

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 Nutanix SDS pool in a modular fashion. While there is no scaling limit of the Nutanix architecture itself, practicality might suggest scaling pods based on the limits of hypervisor clusters (64 nodes for vSphere). Isolating mgmt and compute to their own HA clusters provides more flexibility with regard to scaling and functional layer protection.



Another option is to design a large single contiguous NDFS namespace with multiple hypervisor clusters within to provide single pane of glass management. For example, portrayed below is a 30,000 professional user environment segmented by vSphere HA cluster and broker farm. Each farm compute instance is segmented into an HA cluster with a hot standby node providing N+1, served by a dedicated pair of mgmt nodes in a separate HA cluster. This provides multiple broker farms with separated HA protection while maintaining a single NDFS cluster across all nodes.



- 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.

Component	Metric	Horizontal scalability	Vertical scalability
Virtual Desktop Host/Compute Servers	VMs per physical host	Additional hosts and clusters added as necessary	Additional RAM or CPU compute power
View Composer	Desktops per instance	Additional physical servers added to the Management cluster to deal with additional management VMs.	Additional RAM or CPU compute power
View Connection Servers	Desktops per instance	Additional physical servers added to the Management cluster to deal with additional management VMs.	Additional VCS Management VMs.
VMware vCenter	VMs per physical host and/or ESX hosts per vCenter instance	Deploy additional servers and use linked mode to optimize management	Additional vCenter Management VMs.
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
View Composer	Desktops per instance	Additional physical servers added to the Management cluster to deal with additional management VMs.	Additional RAM or CPU compute power

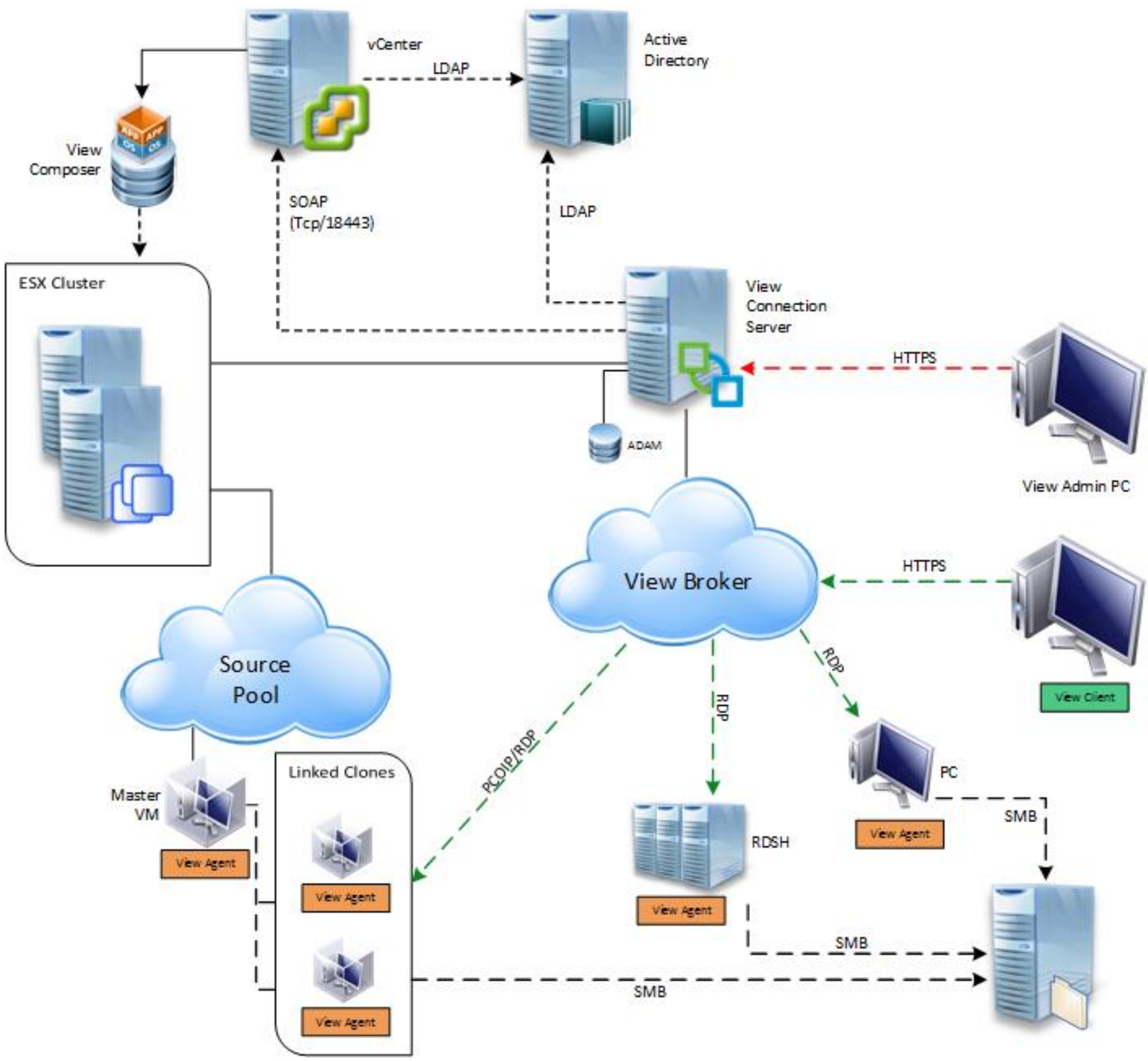
5.5 Solution High Availability

High availability (HA) is offered to protect each architecture solution layer, individually if desired. Following the N+1 model, additional ToR switches 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 both the management and compute layers, SQL is mirrored or clustered and F5 is leveraged for load balancing. Storage protocol switch stacks selection may vary based on chosen solution architecture.

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 mgmt layers to provide N+1 protection.
- Applicable VMware Horizon infrastructure server roles are duplicated and spread amongst mgmt host instances where connections to each are load balanced via the addition of F5 appliances.
- SQL Server databases also are protected through the addition and configuration of an "AlwaysOn" Failover Cluster Instance or Availability Group.

5.6 Dell Wyse Datacenter for Horizon Communication Flow



6 Solution Performance and Testing

6.1 Load Generation and Monitoring

6.1.1 Login VSI 4 – Login Consultants

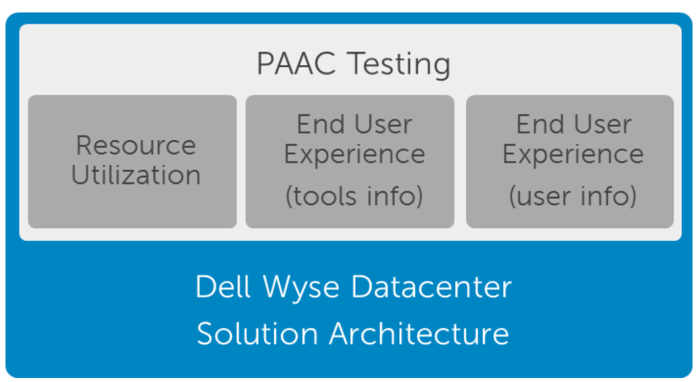
Login VSI is the de-facto industry standard tool for testing VDI environments and server-based computing or RDSH environments. It installs a standard collection of desktop application software (e.g. Microsoft Office, Adobe Acrobat Reader) on each VDI desktop; it then uses launcher systems to connect 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), with the launchers being managed by a centralized management console, which is used to configure and manage the Login VSI environment.

6.1.2 VMware vCenter

VMware vCenter was used for VMware vSphere-based solutions to gather key data (CPU, Memory and Network usage) from each of the desktop hosts during each test run. This data was exported to .csv files for each host and then consolidated to show data from all hosts. While the report does not include specific performance metrics for the Management host servers, these servers were monitored during testing and were seen to be performing at an expected performance level.

6.2 Performance Analysis Methodology

In order 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. This methodology is based on the three pillars shown below. Login VSI is currently the load-testing tool used during PAAC of Dell Wyse Datacenter solutions; Login VSI is the de-facto industry standard for VDI and server-based computing (SBC) environments and is discussed in more detail below.



6.2.1 Resource Utilization

Poor end-user experience is one of the main risk factors when implementing desktop virtualization but the 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 has not happened (and that it is not close to happening), PAAC on Dell Wyse Datacenter solutions monitors the relevant resource utilization parameters and applies relatively conservative thresholds as shown in the table below. As discussed above, these 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. These thresholds are used to decide the number of virtual 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	**85%**
Physical Host Memory Utilization	85%
Network Throughput	85%
Storage IO Latency	20ms

6.2.2 Dell Wyse Datacenter Workloads and Profiles

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. In addition, we use workloads and profiles that are targeted at graphics-intensive use cases. We present more detailed information in relation to these workloads and profiles below but first it is useful to define the terms "workload" and "profile" 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.

User Profile	vCPUs	Memory	ESXi Memory Reservation	Memory Configured	OS
Standard	1	2GB	1GB	2GB	x86
Enhanced	2	3GB	1.5GB	3GB	x86
Professional	2	4GB	2GB	4GB	x64

6.2.3 Dell Wyse Datacenter Workloads

Load-testing on each of the profiles described in the above table is carried out using an appropriate workload that is representative of the relevant use case. In the case of the non-graphics workloads, these workloads are Login VSI workloads and in the case of graphics workloads, these are specially designed workloads that stress the VDI environment to a level that is appropriate for the relevant use case. This information is summarized in the table below:

Profile Name	Workload	OS Image
Standard	Login VSI Light	Shared
Enhanced	Login VSI Medium	Shared
Professional	Login VSI Heavy	Shared + Profile Virtualization
Graphics	eFigures / AutoCAD - SPEC Viewperf	Persistent

Further information for each of the workloads is given below. It is noted that for Login VSI testing, the following login and boot paradigm is used:

- For single-server / single-host testing (typically carried out to determine the virtual desktop capacity of a specific physical server), users are logged in every 30 seconds.
- For multi-host / full solution testing, users are logged in over a period of 1-hour, to replicate the normal login storm in an enterprise environment.
- All desktops are pre-booted in advance of logins commencing.
- For all testing, all virtual desktops run an industry-standard anti-virus solution (currently McAfee VirusScan Enterprise) in order to fully replicate a customer environment.

6.2.3.1 Login VSI Light Workload

Compared to the Login VSI medium workload described below, the light workload runs fewer applications (mainly Excel and Internet Explorer with some minimal Word activity) and starts/stops the applications less frequently. This results in lower CPU, memory and disk IO usage.

6.2.3.2 Login VSI Medium Workload

The Login VSI medium workload is designed to run on 2vCPU's per desktop VM. This workload emulates a medium knowledge worker using Office, IE, PDF and Java/FreeMind. The Login VSI medium workload has the following characteristics

- Once a session has been started the workload will repeat (loop) every 48 minutes.
- The loop is divided in four segments; each consecutive Login VSI user logon will start a different segment. This ensures that all elements in the workload are equally used throughout the test.
- The medium workload opens up to five applications simultaneously.
- The keyboard type rate is 160 ms for each character.
- Approximately two minutes of idle time is included to simulate real--world users.

Each loop opens and uses:

- 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.

6.2.3.3 Login VSI Heavy Workload

The heavy workload is based on the medium workload except that the heavy workload:

- Begins by opening four instances of Internet Explorer. These instances stay open throughout the workload loop.
- Begins by opening two instances of Adobe Reader. These instances stay open throughout the workload loop.
- There are more PDF printer actions in the workload.
- Instead of 480p videos a 720p and a 1080p video are watched.
- Increased the time the workload plays a flash game.
- The idle time is reduced to two minutes.

6.2.3.4 Workloads Running on Shared Graphics Profile

Graphics hardware vendors (e.g. NVIDIA) typically market a number of graphics cards that are targeted at different markets. Consequently, it is necessary to provide two shared graphics workloads – one for mid-range cards and the other for high-end cards. These workloads are described in more detail below. It is noted that technologies such as the VMware / NVIDIA GRID vGPU technology (where the NVIDIA drivers reside on the virtual desktop, giving shared-level density with near pass-through functionality) mean that in some cases, the higher-end workloads, traditionally used for pass-through GPU PAAC, may be more appropriate for shared GPU PAAC. Such scenarios will explicitly state the workload used.

6.3 Testing and Validation

6.3.1 Testing Process

The purpose of the single server testing is to validate the architectural assumptions made around the server stack. Each user load is tested against four runs. A pilot run is conducted to validate that the infrastructure is functioning and valid data is captured. Subsequently three more runs are conducted allowing for correlation of data. Summary of the test results is listed out in the below mentioned tabular format.

At different stages of the 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 is 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.

Login VSI has two modes for launching user's sessions:

- Parallel

Sessions are launched from multiple launcher hosts in a round robin fashion; this mode is recommended by Login Consultants when running tests against multiple host servers. In parallel mode the VSI console is configured to launch a number of sessions over a specified time period (specified in seconds)

- Sequential

Sessions are launched from each launcher host in sequence, sessions are only started from a second host once all sessions have been launched on the first host and this is repeated for each launcher host. Sequential launching is recommended by Login Consultants when testing a single desktop host server. The VSI console is configure to launch a specified number of session at a specified interval specified in seconds

All test runs which involved the six desktop hosts were conducted using the Login VSI "Parallel Launch" mode and all sessions were launched over an hour to try and represent the typical 9am logon storm. Once the last user session has connected, the sessions are left to run for 15 minutes prior to the sessions being instructed to logout at the end of the current task sequence, this allows every user to complete a minimum of two task sequences within the run before logging out. The single server test runs were configured to launch user sessions every 60 seconds, as with the full bundle test runs sessions were left to run for 15 minutes after the last user connected prior to the sessions being instructed to log out.

6.4 XC630-B5 Test Results for VMware Horizon

Validation for this project was completed for VMWare View on the following platforms.

ESXi 5.5 U2 / VMware View 6.0/ XC630
ESXi 5.5 U2 / RDSH brokered by VMware Horizon 6.0/ XC630

Platform configurations are shown below and the Login VSI workloads used for load testing on each environment.

Platform	Config	CPU	RAM	RAID Ctlr	HD Config	Network
XC630	B5	E5-2690v3 (12Core, 2.6GHz)	512GB	H730P	1 X 64GB SATADOM **(CVM/ HV)**	2 x 10Gb, 2 x 1Gb SFP+/ BT
					2 x 400GB, Intel S3700, SATA SSD's 2.5" (T1)	
					4 x 1TB NL SAS 2.5" (T2)	

1GB networking was used for the deployment of the Dell XC appliances while all 10GB networking was used for the PAAC testing.

Compute and Management resources were split out with the following configuration across a three node Nutanix cluster and all test runs were completed with this configuration.

- Node 1 – XC630– Dedicated Management (vCenter Appliance, SQL Server, Horizon Delivery Controller, Horizon Storefront.)
- Node 2 – XC630– Dedicated Compute
- Node 3 –XC630 – Dedicated Compute

Please refer to section 5.1 of this document for the configuration of each management virtual machine.

The virtual machines were non-persistent linked clone desktops each configured on Windows 8.1 aligning with the Login VSI 4.X virtual machine configuration, Office 2010 was used with each Virtual Machine sized at 32 GB. User Workload configuration of the load generation virtual machines is shown in the table below.

User Workload	vCPUs	Memory	OS Bit Level	HD Size GB
Professional User	2	4GB	x64	32

The RDSH environment was configured as shown in the table below for each host according to platform. The RDSH images were built using Windows Server 2012 R2 Standard edition and Microsoft Office 2010 plus the support tools required for Login VSI testing.

Role	Config	VMs per host	vCPUs	RAM (GB)	NIC	Disk Size GB
RDSH VM	B5	5	8	32	1	80

Validation was performed using CCC standard testing methodology using LoginVSI 4 load generation tool for VDI benchmarking that simulates user workloads.

Each test run adhered to PAAC best practices with a 30 second session logon interval, 16 minutes of steady state after which user sessions would begin logging off.

The following table summarizes the test results for the various workloads and configurations.

Hyper-visor	Provisioning	Workload	Density Per Host	Avg CPU	Avg Memory Consumed	Avg Memory Active	Avg IOPS/ User	Avg Net /User
ESXi	View	Light	205	95%	247 GB	61 GB	3.4	152 Kbps
ESXi	View	Medium	130	95%	193 GB	50 GB	5.4	422 Kbps
ESXi	View	Heavy	95	95%	210 GB	42 GB	6.6	777 Kbps
ESXi	RDSH	Heavy	120	98%	97 GB	21 GB	2.8	372 Kbps

CPU Utilization* CPU % for ESX Hosts was adjusted to account for the fact that on Intel E5-2690v3 series processors the ESX host CPU metrics will exceed the rated 100% for the host if Turbo Boost is enabled (by default). The Adjusted CPU % Usage is based on 100% usage and but is not reflected in the charts. The figure shown in the table is the Compute host steady state peak CPU Usage. One Nutanix CVM Controller virtual machine is located on each node and is allocated 10000MHz of CPU reservation.

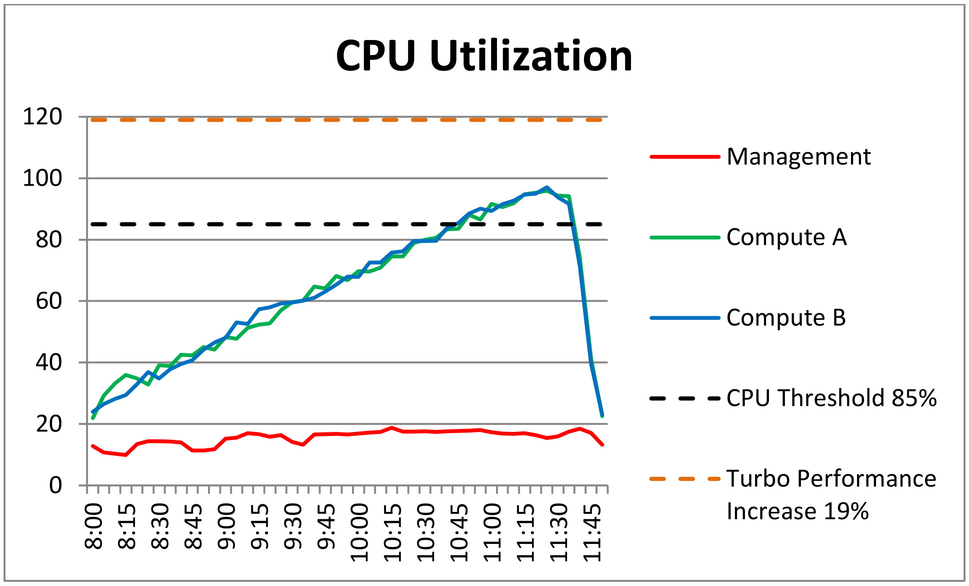
Memory Utilization. The figure shown in the table above is the average memory **consumed** per Compute host over the recorded test period. Active is the average **active** memory per Compute host over the recorded test period. Consumed is the total amount assigned to all VMs, active is memory actually in use.

The IOPS results are calculated from the average Nutanix **Cluster Disk IOPS** figure over the test period divided by the number of users.

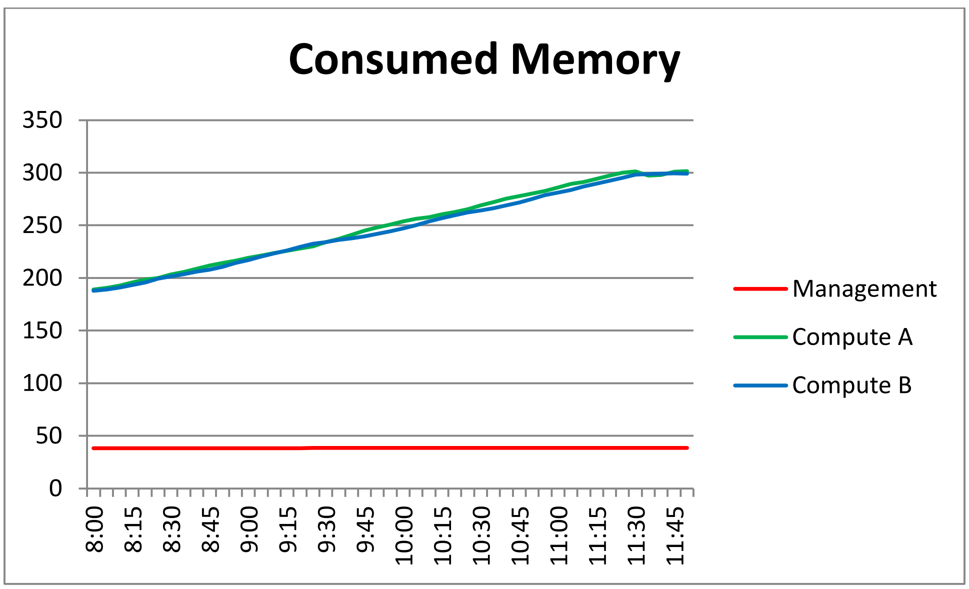
Network Utilization The figure shown in the table is the average **Kbps/User per Compute host** over the recorded test period.

6.4.1 Horizon, 410 Linked Clones, Light Workload – XC630-B5

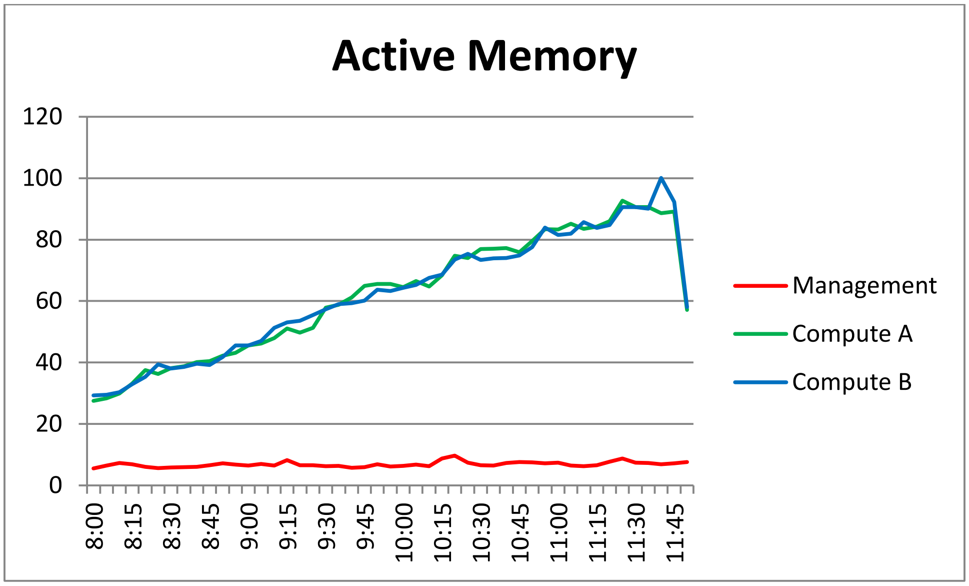
95% Steady State Average



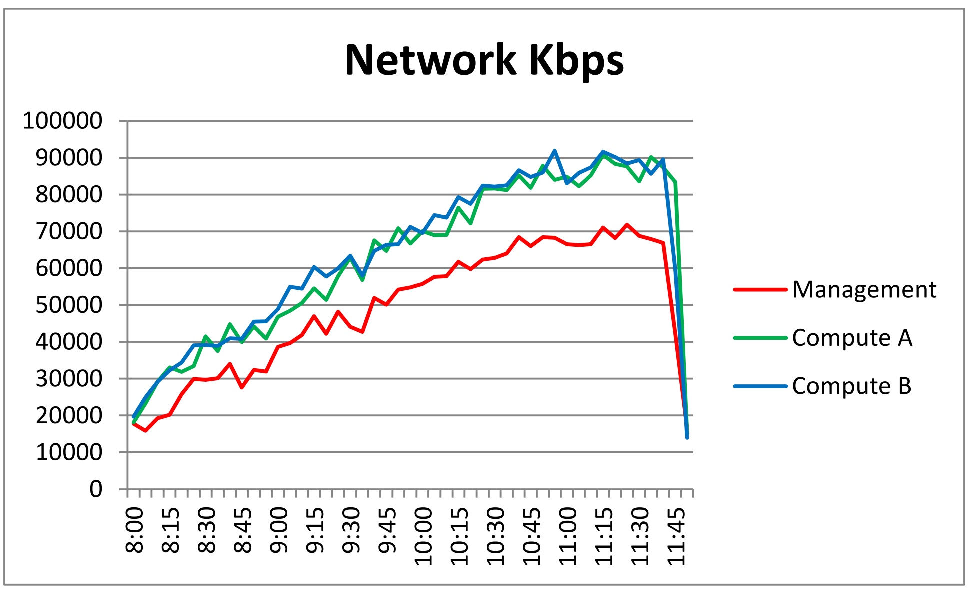
Max Consumed Memory 301GB



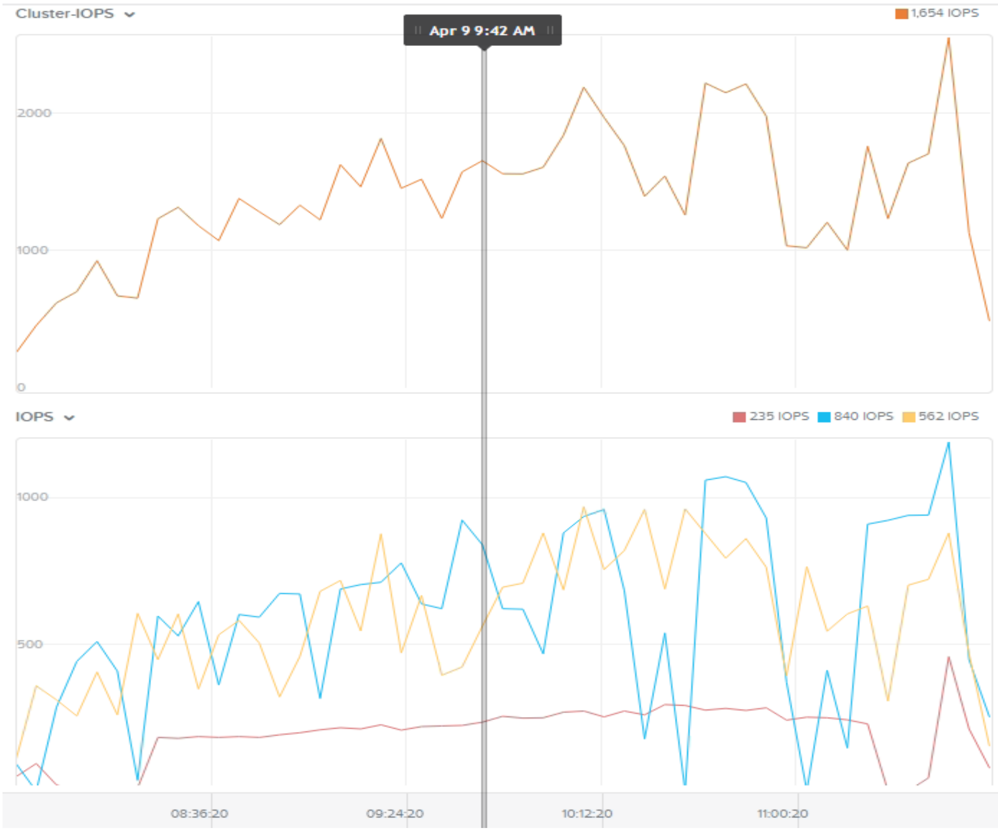
Max Active Memory 100GB



Network Kbps Peak 91Mbps

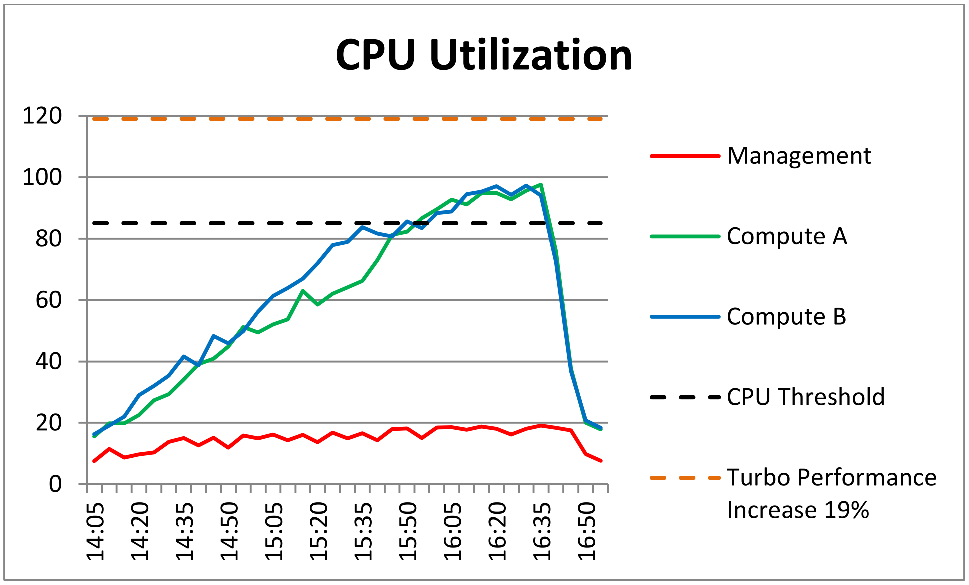


Cluster IOPS Peak 2551 IOPS

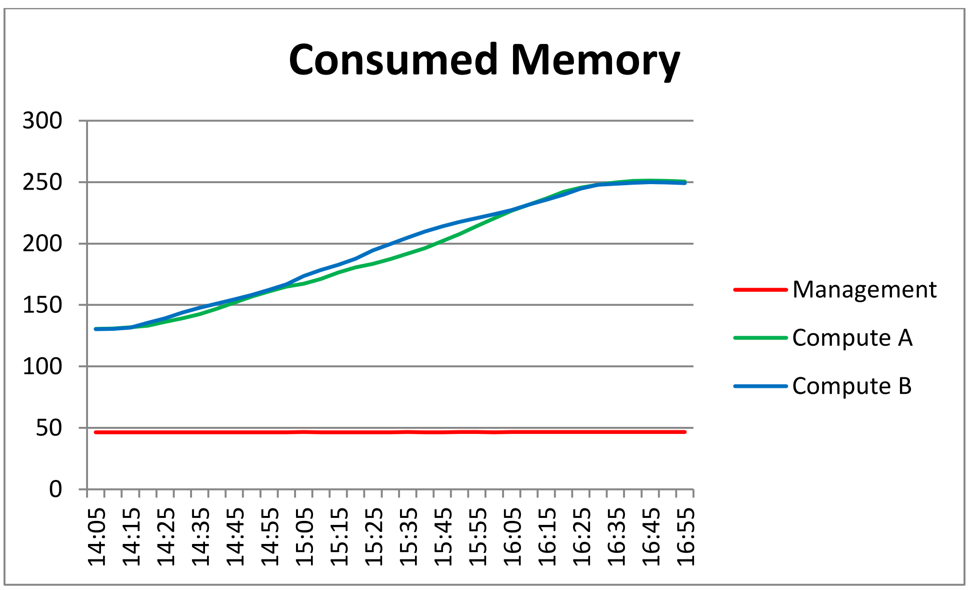


6.4.2 Horizon, 260 Linked Clones, Medium Workload – XC630-B5

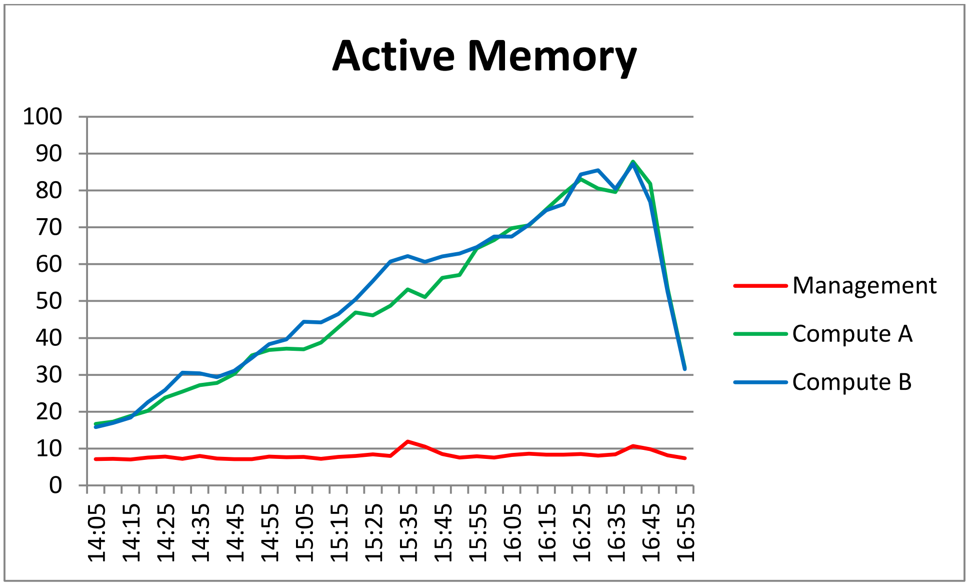
95% Steady state average.



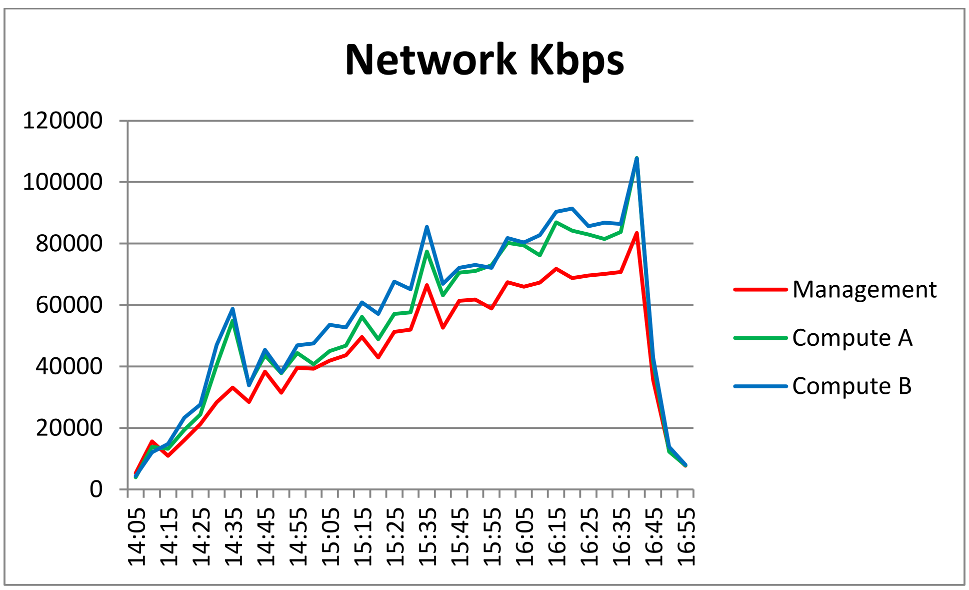
Max Consumed Memory 251GB



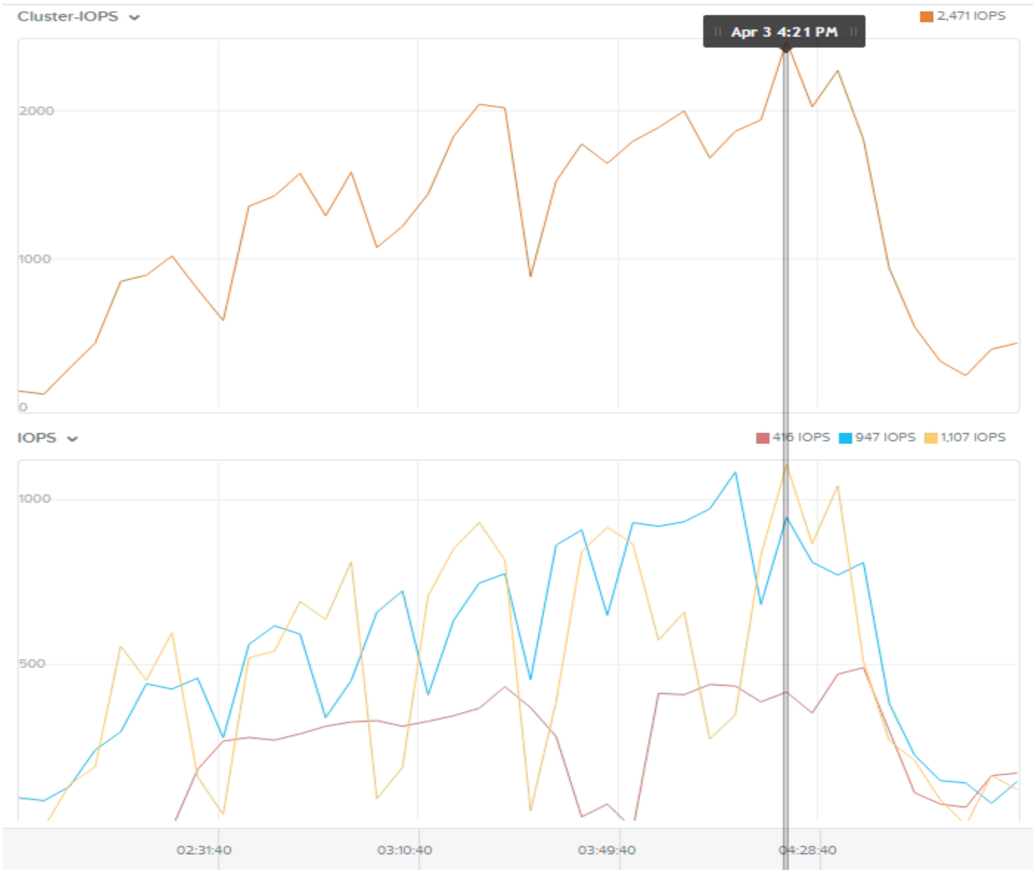
Max Active Memory 87GB



Network Peak 107Mbps.

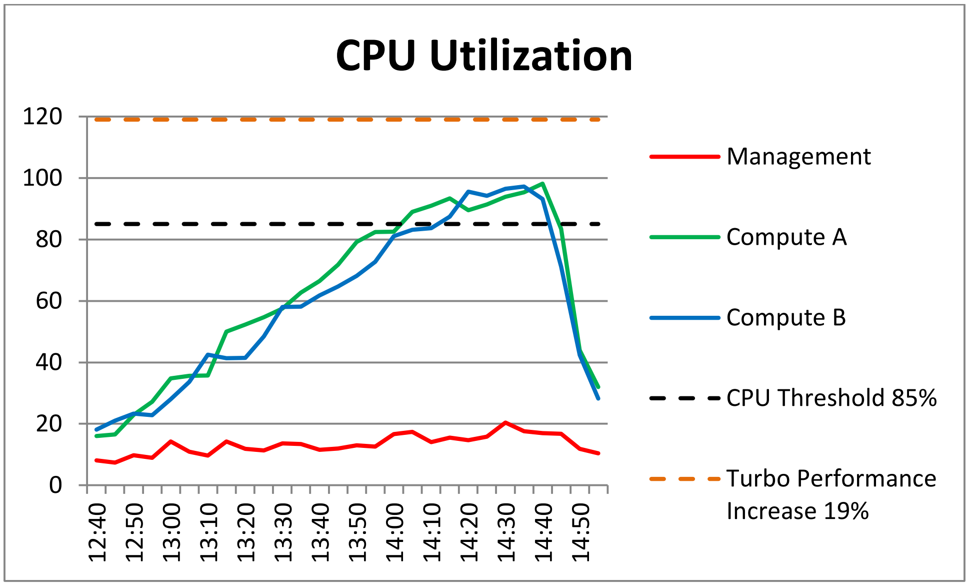


Cluster IOPS Peak 2471

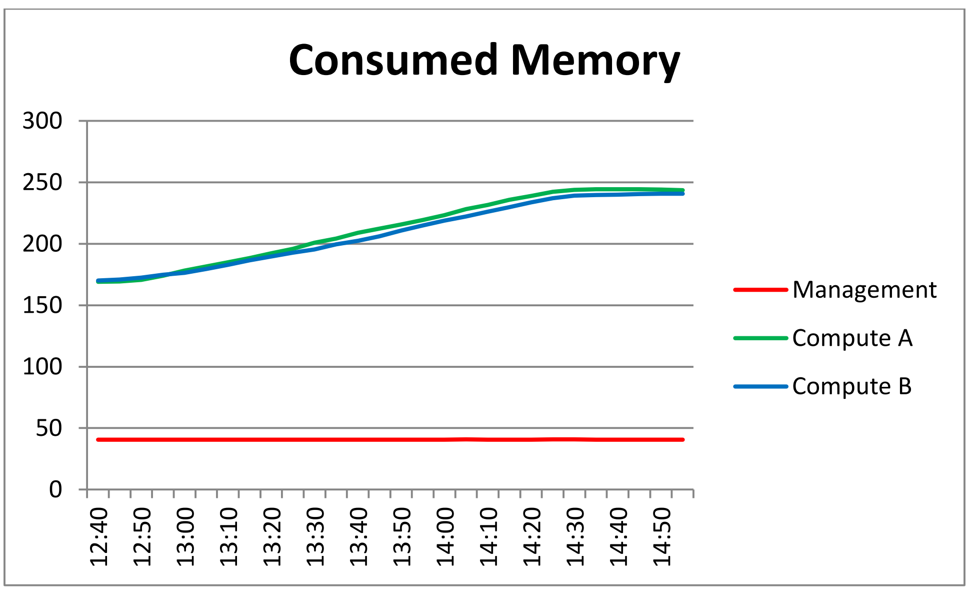


6.4.3 Horizon, 190 Linked Clones, Heavy Workload – XC630-B5

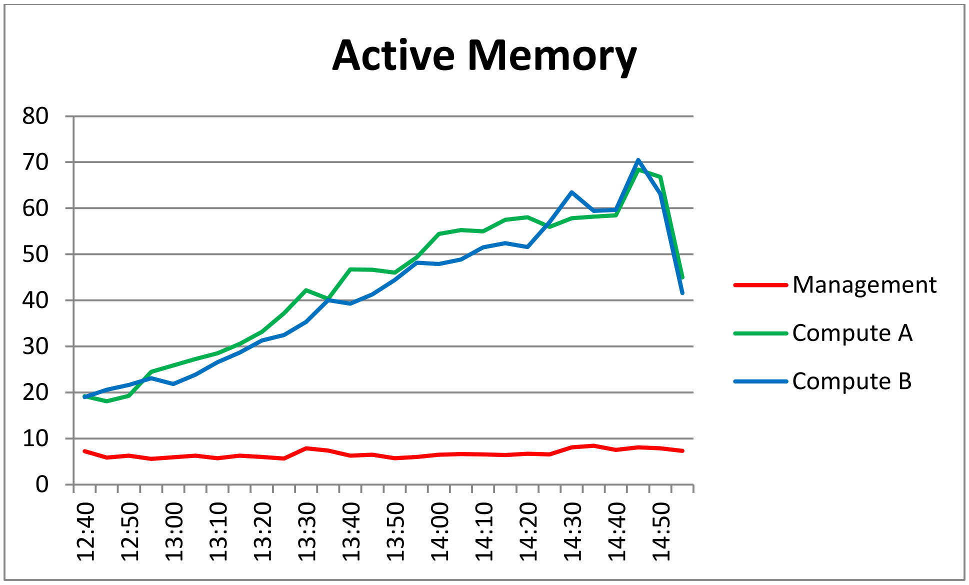
Steady state peak average: 95%



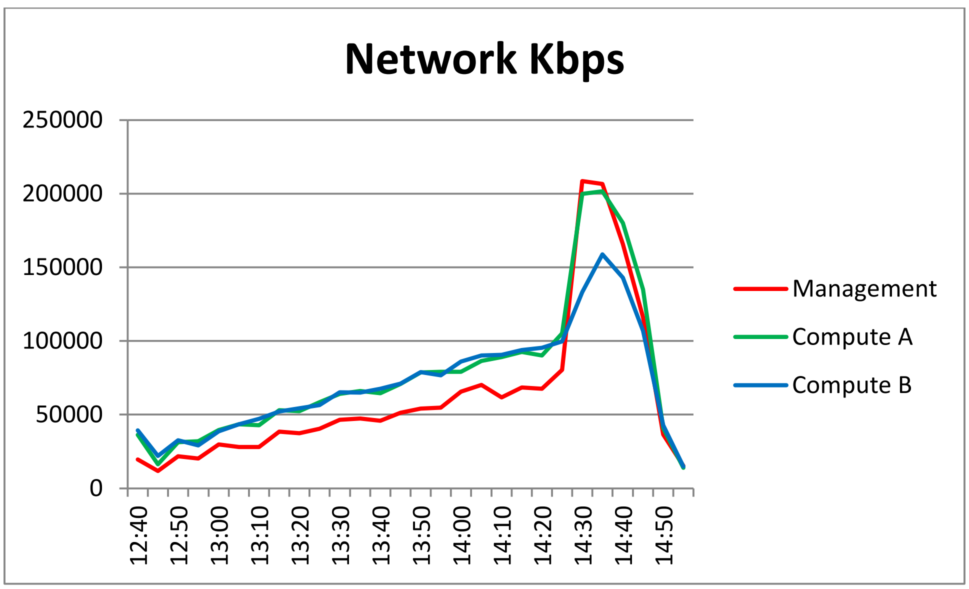
Max consumed memory 244GB



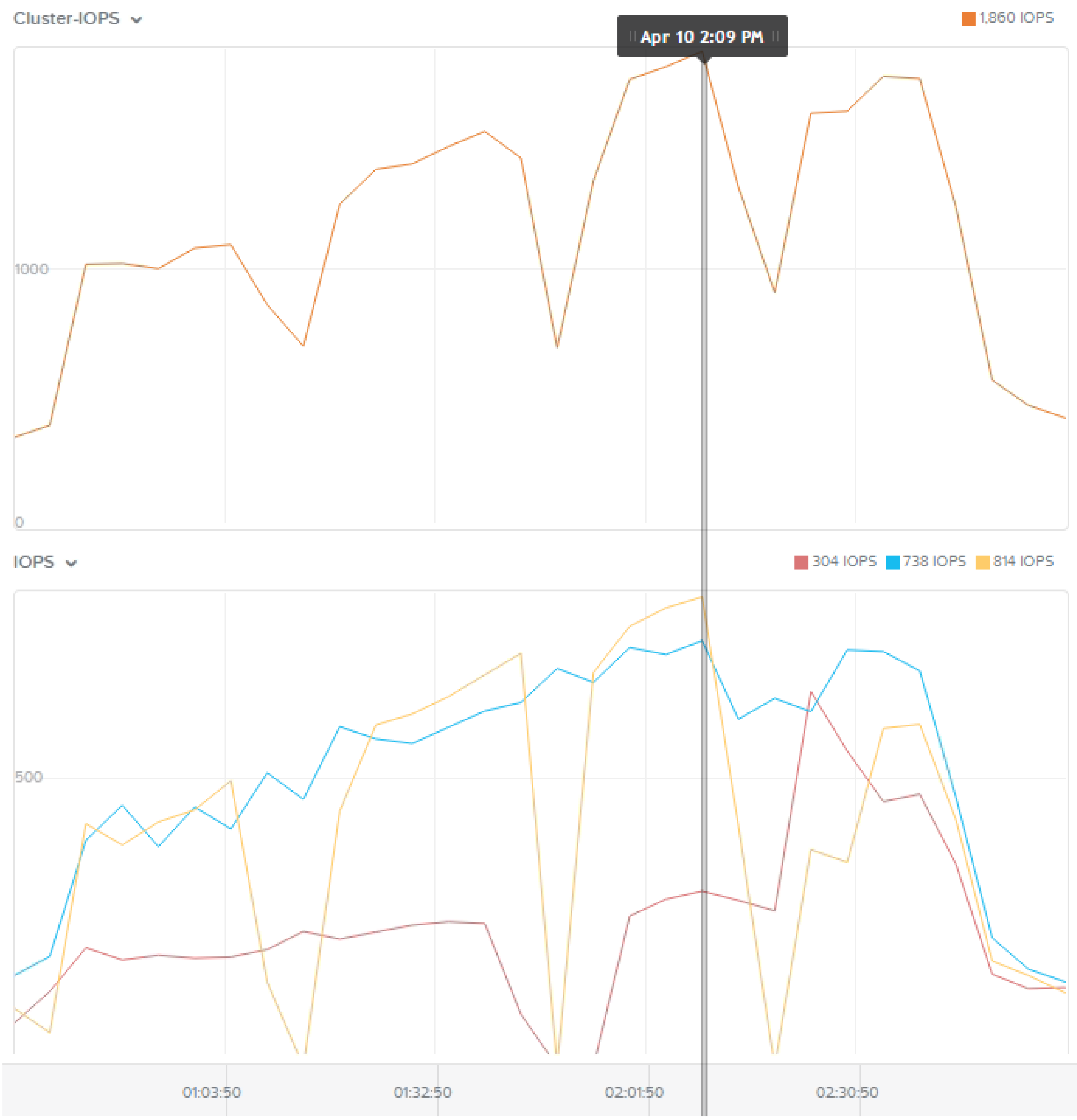
Max active memory 70GB



Network utilization 201MBps



Cluster IOPS Peak 1860



6.4.4 Horizon, 240 RDSH Sessions, Heavy Workload – B5

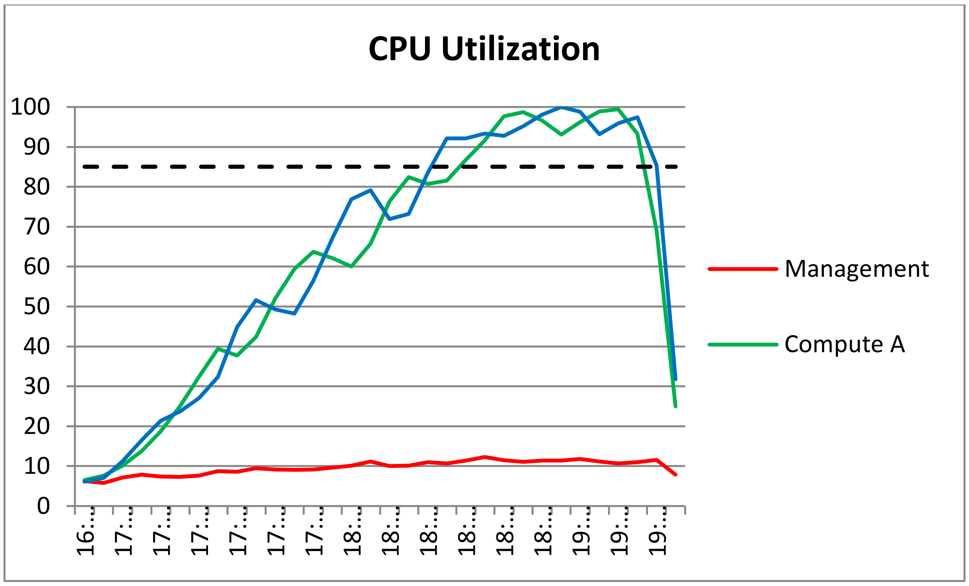
The architecture for this solution includes a dedicated management host and two compute hosts. Each of the compute hosts were populated with 5 RDS session host virtual machines running Windows Server 2012 R2 and one Nutanix CVM per host. Each session host vm was allocated 32GB of RAM and 8vCPU's.

The Nutanix CVM's took up approximately 4% of the compute hosts CPU Usage at the start of the test run.

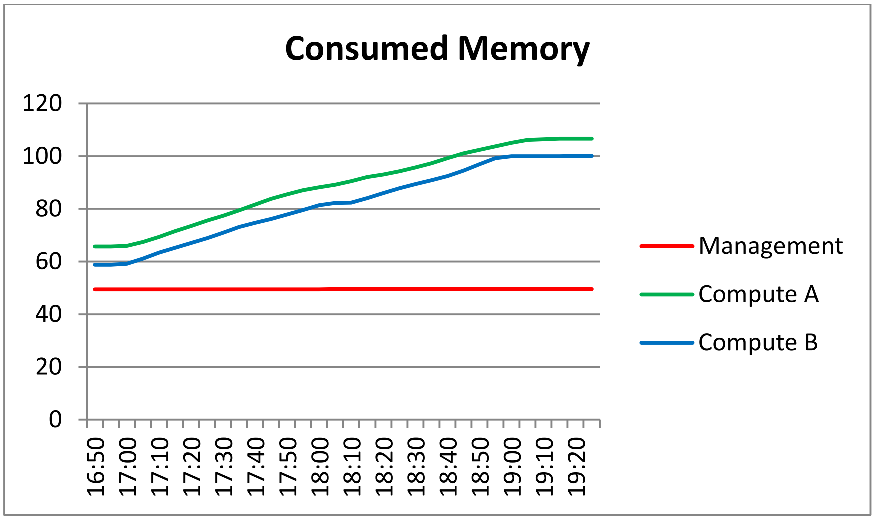
This chart does not include the additional 10% of CPU available from the Turbo boost feature. Without the inclusion there is a total of 62380 MHz available for Desktops, with Turbo boost the total available MHz value is 68168 MHz.

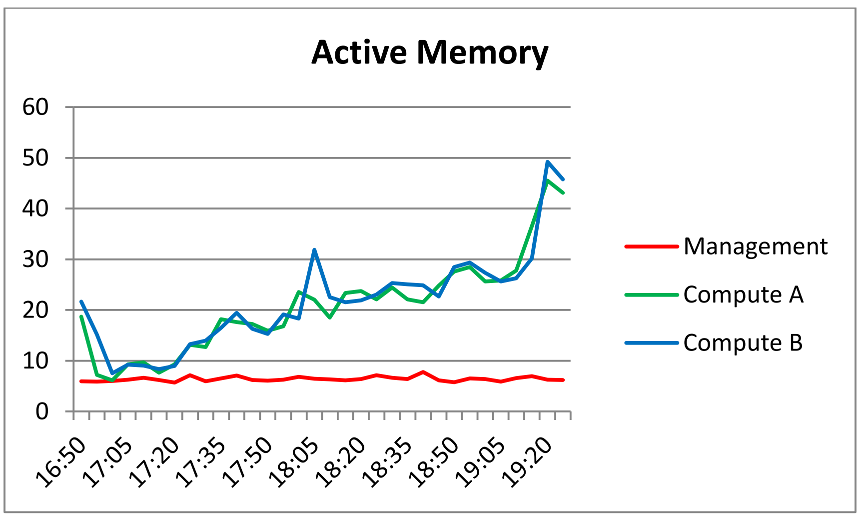
The below graph shows the performance data for 120 user sessions per host on a pair of Compute hosts. The CPU reaches a steady state peak of 98% during the test cycle when approximately 120 users are logged on to each compute host.

The Management host in the cluster runs the vSphere management virtual machines and a Nutanix CVM virtual machine. Its CPU utilization is significantly lower than the compute hosts in the cluster. The CPU utilization for the management host does not exceed 13% at any point in the test cycle.

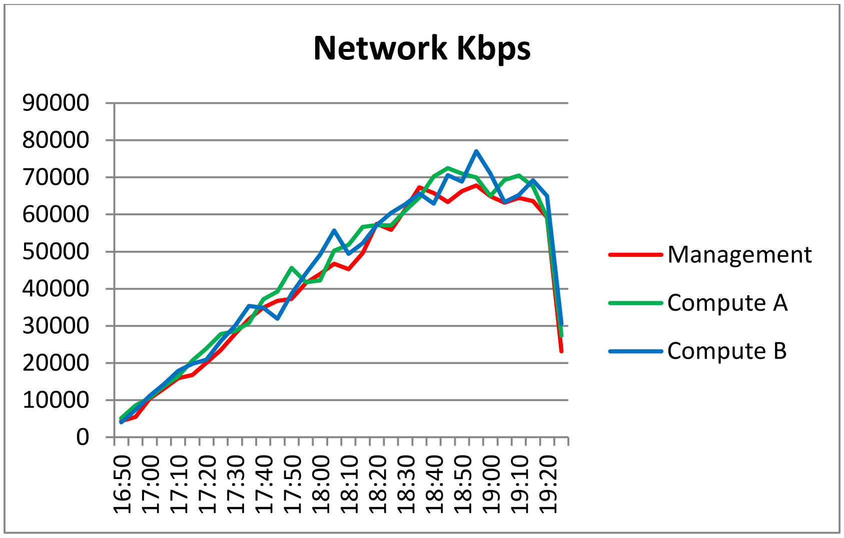


In regards to memory consumption for the cluster, out of a total of 512 GB available memory per node there were no constraints for any of the hosts. The Compute Hosts reached a max memory consumption of 106 GB with active memory usage reaching a max of 49GB. There was no memory ballooning or swapping.

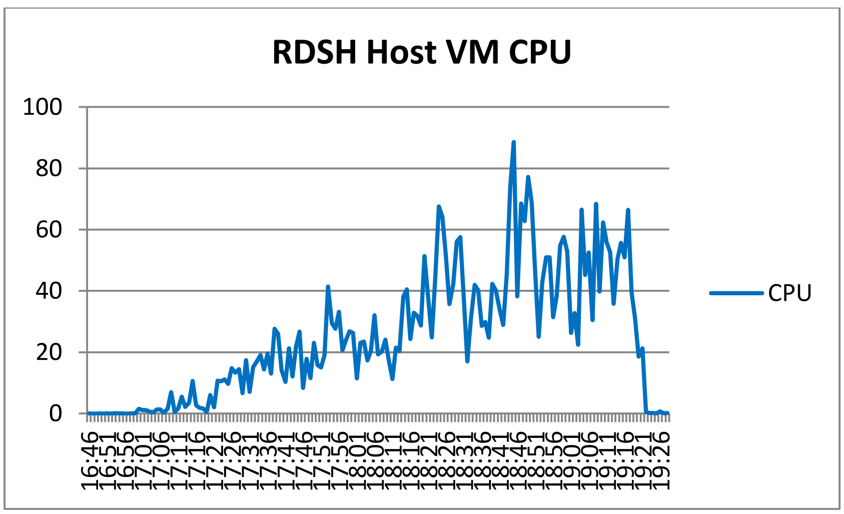




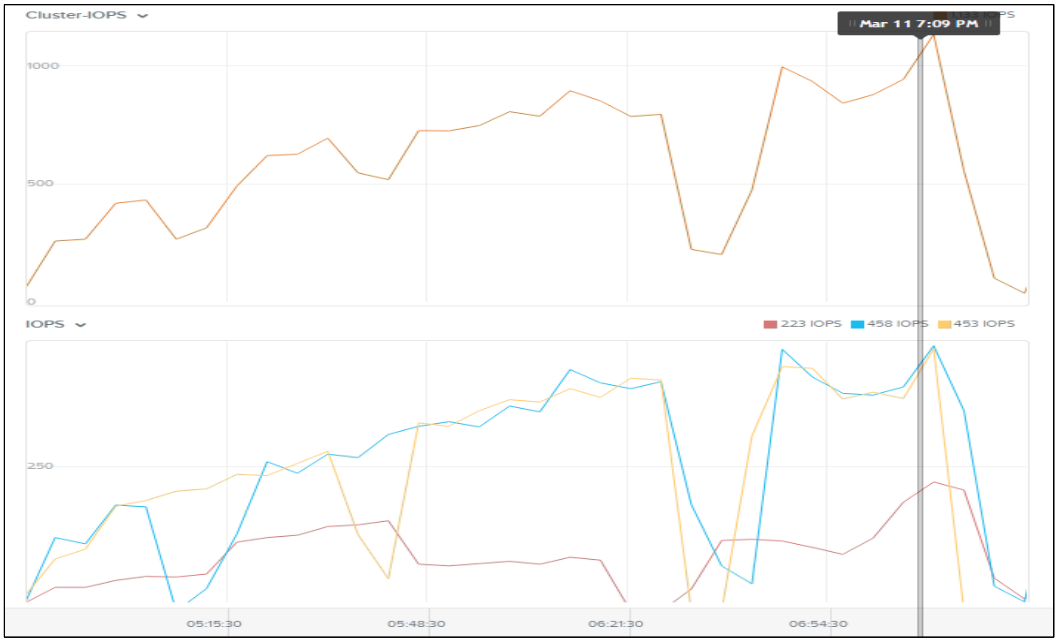
Network bandwidth is not an issue on this solution with a steady state peak of approximately 70,000 Kbps and a spike to 77,000 Kbps during the period of desktop session logoff's.



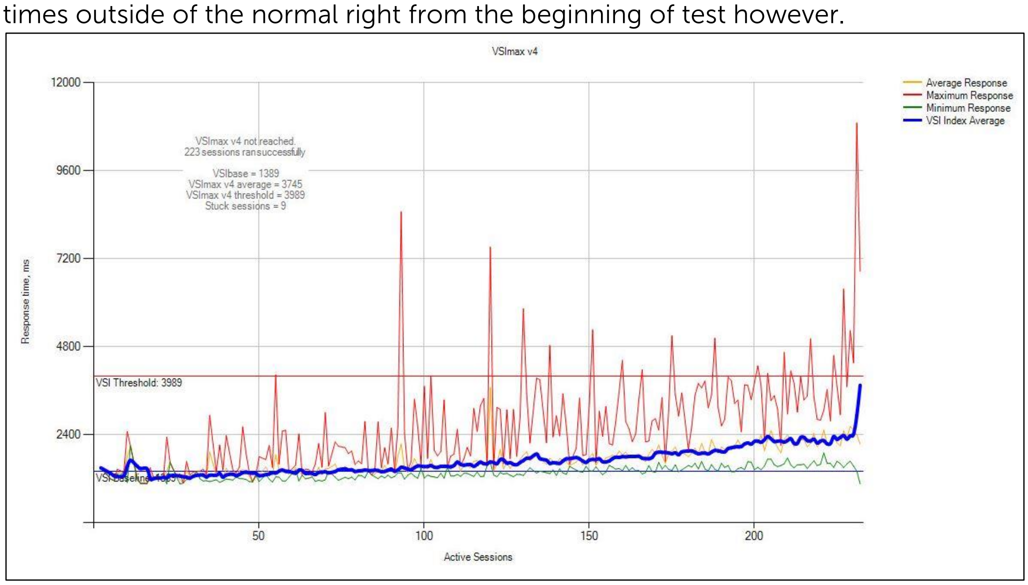
Monitoring of a single, sample RDSH session host showed that its processor reached a maximum of 88% during the test run.



The Nutanix Cluster IOPS figures taken from the Nutanix Web Console showed that the cluster reached a maximum of 1133 Disk IOPS during the test run with the Management node having the lowest disk IOPS of the three nodes.



The Login VSI Max user experience score for this test indicates that the VSI Max score not reached so there should have been little deterioration of user experience during testing. There were some erratic login times outside of the normal right from the beginning of test however.



Notes:

- As indicated above, the CPU graphs do not take into account the extra 10% of CPU resources available through the 2690v3's turbo feature.
- Subjective user experience showed mouse movement and window response times when clicking within a running session during steady state were good. Video playback was good quality with no jumpy playback even with the maximum amount of users logged on.
- User login times were a bit erratic from the beginning of the test cycle with some taking extra time to login.
- 512 GB of memory installed on each node is more than enough for this configuration and should run equally well with less memory installed.

6.5 XC630-B7 Test Results for VMware Horizon

This range of tests was run on a Dell XC 2.0 B7 configuration which includes a dedicated management host and two compute hosts, each with 2 X E5-2698-v3 16-core processors Each compute host was populated with linked clone virtual machines to determine the desktop density number for each workload (Standard, Enhanced and Professional) and one Nutanix CVM per host. VMware ESXi 5.5 was used as the hypervisor and VMware View 6.0 for desktop provisioning.

Testing was also carried out with Microsoft RDS to determine the maximum number of desktop terminal services sessions that could be provided using RDSH session host servers per compute host. The RDSH servers were assigned to specific physical CPU sockets using affinity rules, four RDSH servers were assigned to one CPU and three plus the Nutanix CMV assigned to the other.

Provisioning	Workload	Density Per Host	Avg CPU %	Avg Memory Consumed	Avg Memory Active	Avg IOPS/User	Avg Net Kbps/User
View	Heavy	120	96%	213 GB	53 GB	5.3	596 Kbps
View	Medium	165	97%	239 GB	63 GB	4.8	396 Kbps
View	Light	250	95%	289 GB	70 GB	3.6	279 Kbps
RDSH	Medium	200	95%	96 GB	26 GB	1.8	329 Kbps

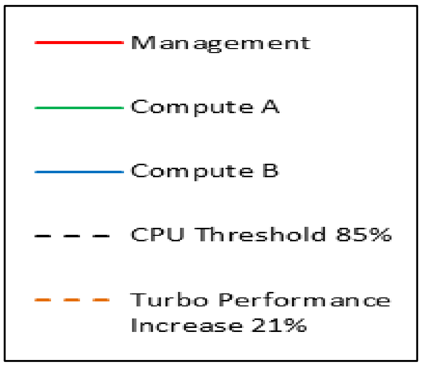
The Nutanix CVM's consumed 4% of the compute hosts CPU Usage for RDSH Workloads up to 19% of CPU Usage for the Standard workload test. This figure varies according to the number of virtual machines powered on, on each host.

The CPU was pushed to approximately a 96% steady state peak usage across each test category and the number of desktops used to achieve this level of CPU usage is used as the density number.

This chart does not include the additional 21% of CPU available from the Turbo boost feature; however this is indicated as a threshold line on the graphs. With the Turbo feature enabled and active across all 16 cores on the E5-2698-v3 processor, the processor speed is boosted from 2.3GHz to 2.8GHz. Without the inclusion of Turbo there is a total of 73,600 MHz available for desktops, with Turbo boost the total available MHz value is 89,056 MHz.

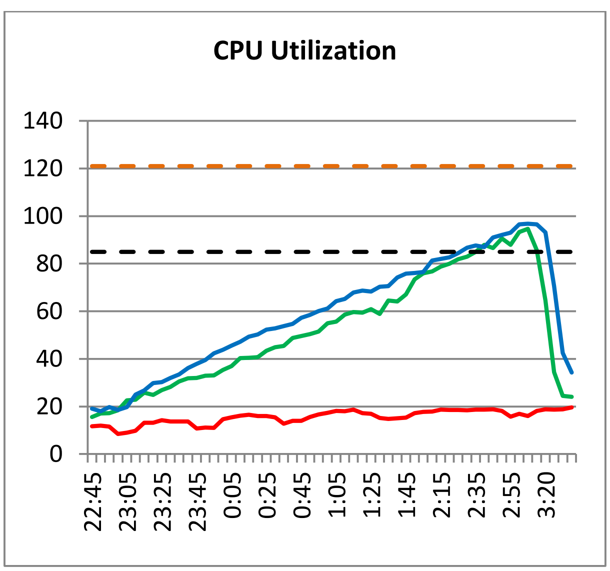
With 512 GB of physical memory and 10Gbe networking, there were no memory or network resource issues across all testing.

Key for tables below

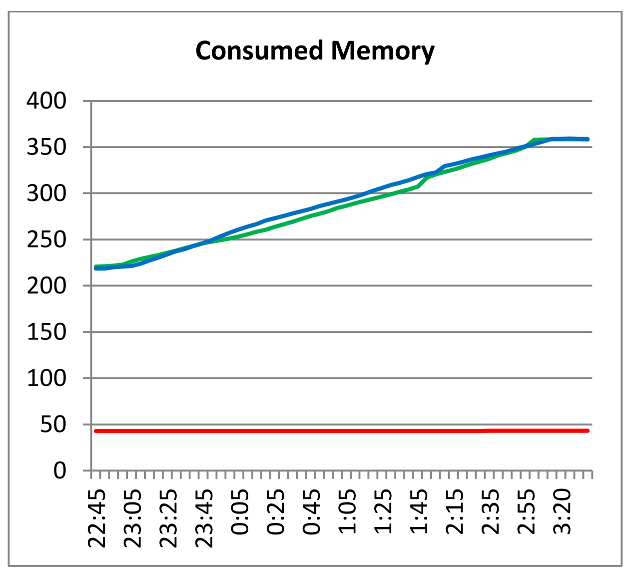


6.5.1 Horizon, 500 Linked Clones, Light Workload – B7

Max CPU 96% Steady State Peak Average – 95%

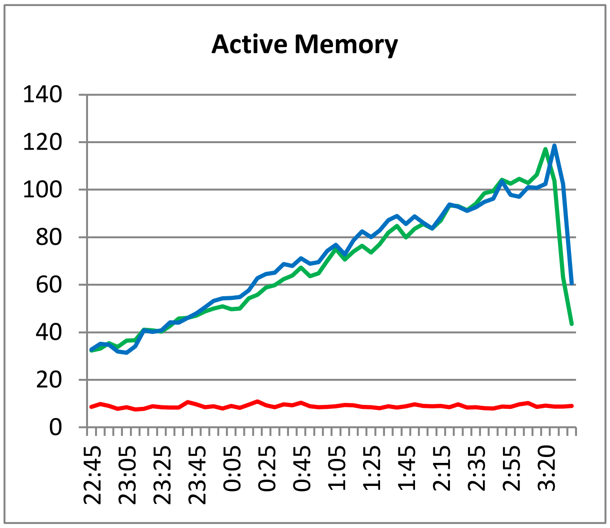


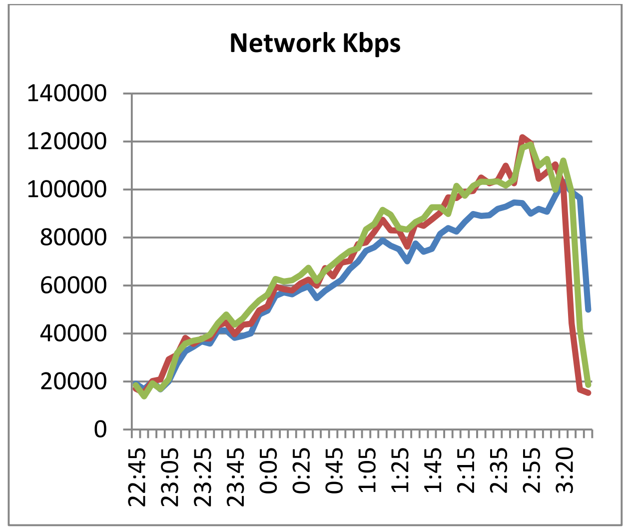
Max Consumed Memory 359 GB



Max Active Memory 118 GB

Network 121,000 Kbps Peak

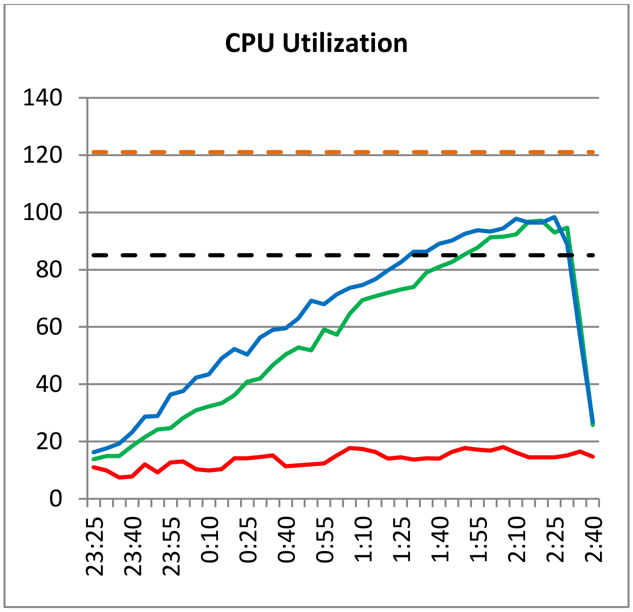


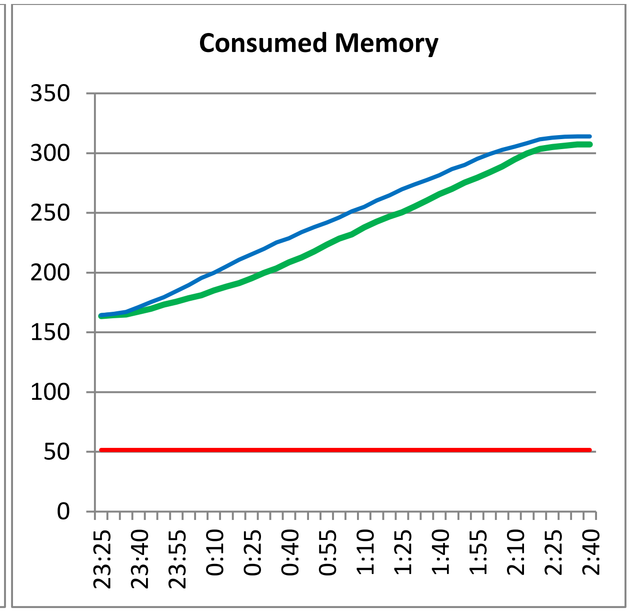


6.5.2 Horizon, 330 Linked Clones, Medium Workload – B7

Max CPU 98 % Steady State Peak Average – 97 %

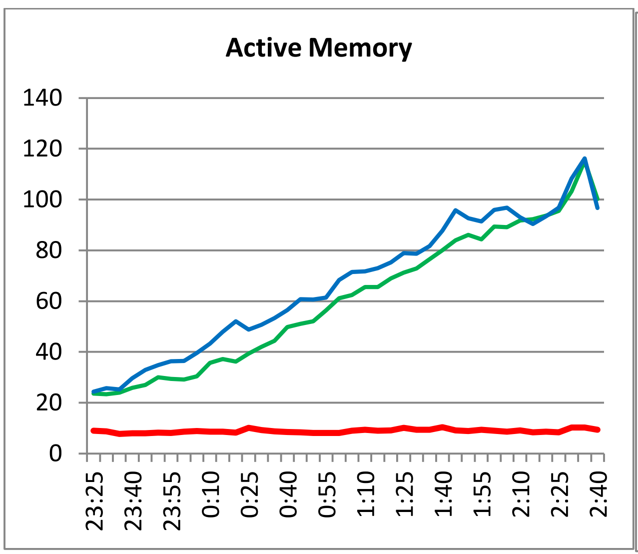
Max Consumed Memory 314 GB

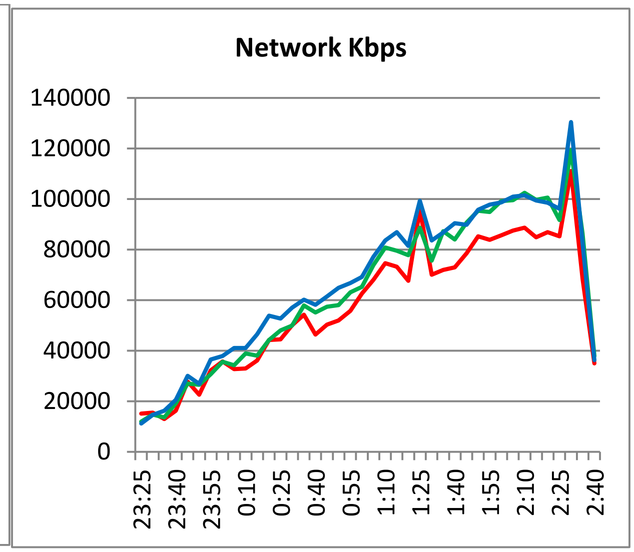




Max Active Memory 116 GB

Network 130,000 Kbps Peak

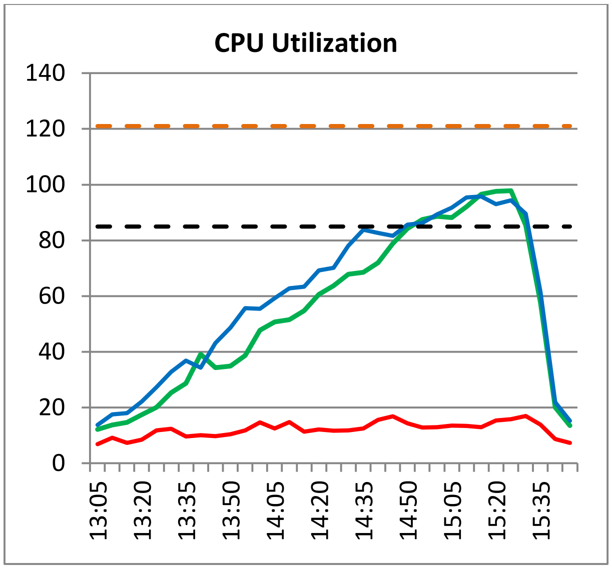


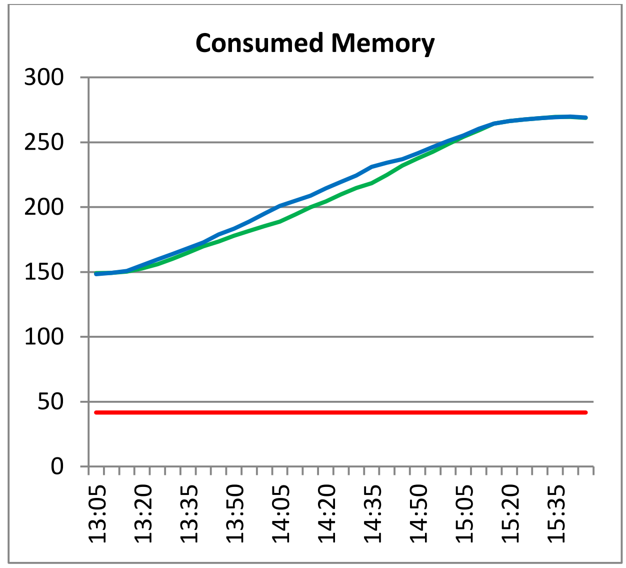


6.5.3 Horizon, 240 Linked Clones, Heavy Workload – B7

Max CPU 97 % Steady State Peak Average – 96 %

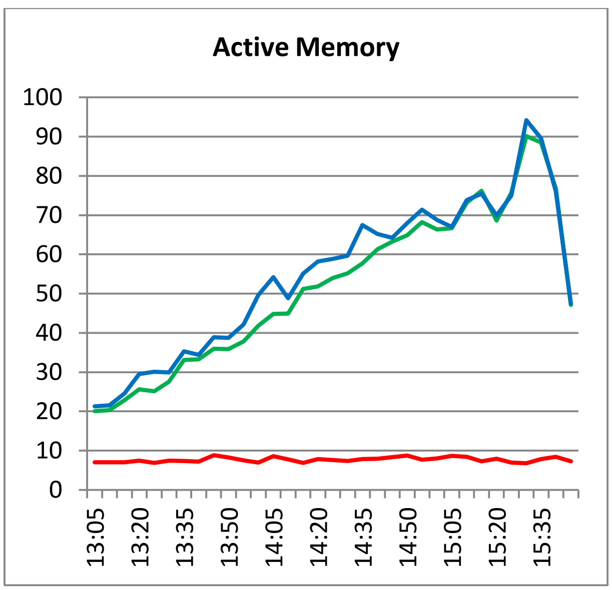
Max Consumed Memory 269 GB

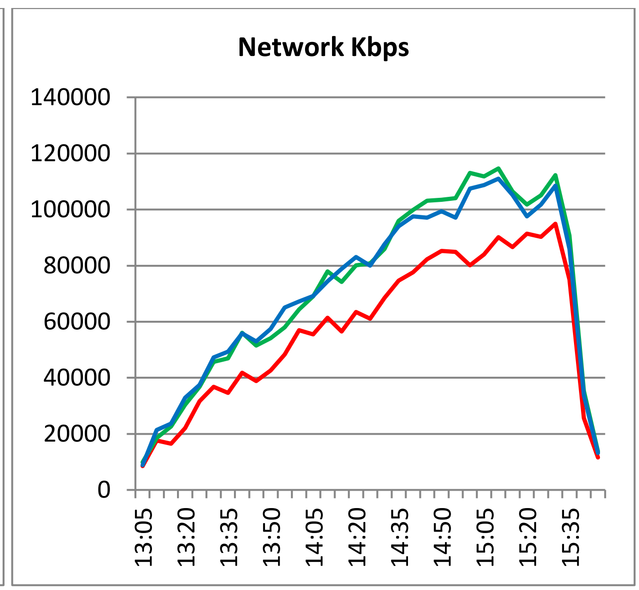




Max Active Memory 90 GB

Network 112,000 Kbps Peak

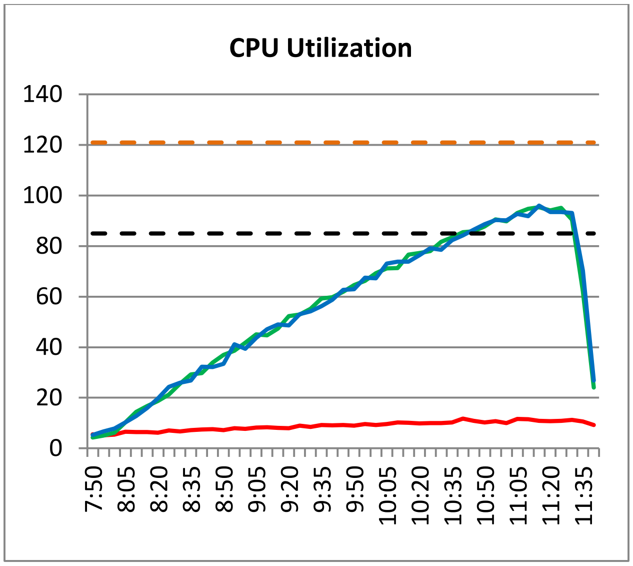


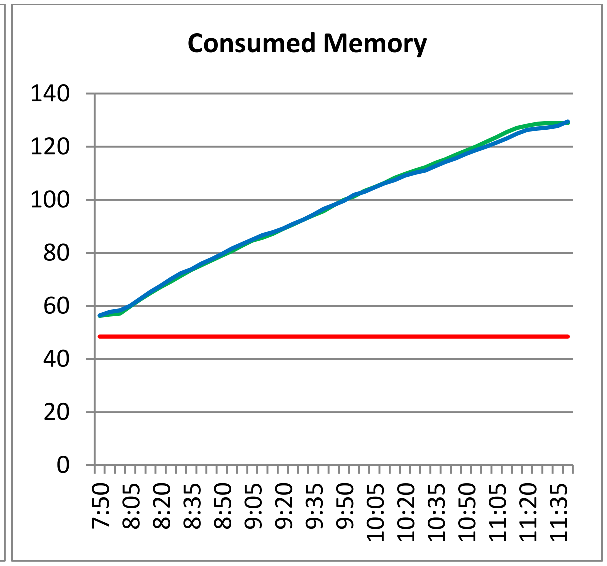


6.5.4 Horizon, 400 RDSH Sessions, Medium Workload – B7

Max CPU 96% Steady State Peak Average – 95%

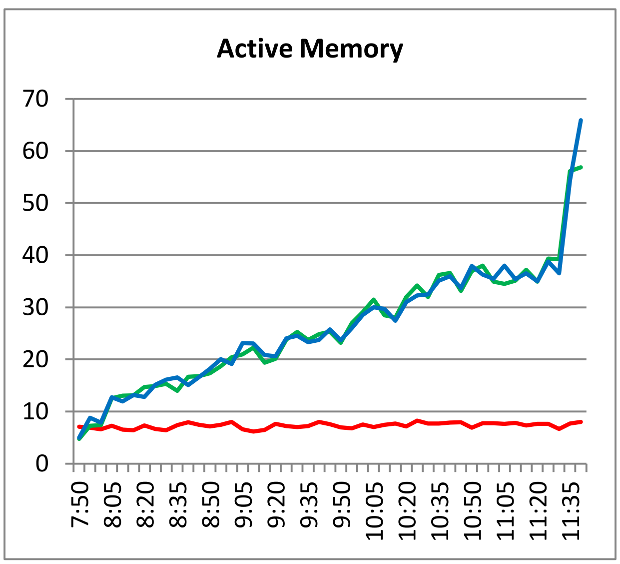
Max Consumed Memory 129 GB

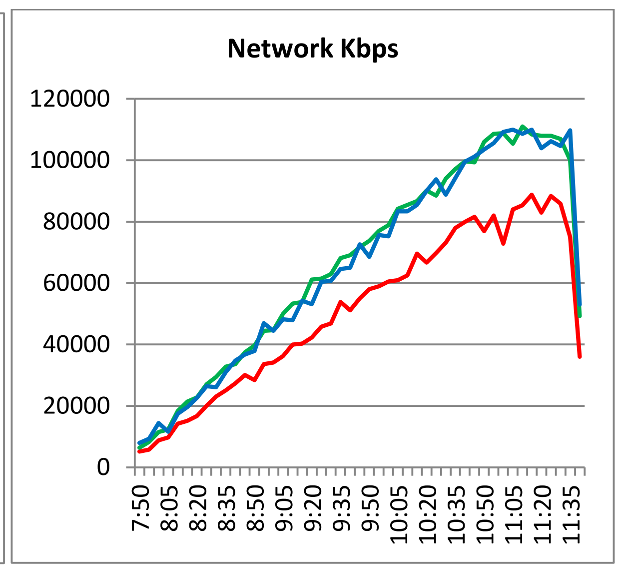




Max Active Memory 65 GB

Network 109,000 Kbps Peak





6.6 XC730 Test Results for VMware Horizon with Graphics

This document contains the test results for validating server-side shared graphics on a four node XC730 cluster with NVIDIA K2 graphics cards.

The test objectives were to validate server-side performance and determine the performance impact of using high end graphics cards on a 4 node Nutanix cluster.

The test infrastructure includes:

- A four node XC730 Nutanix cluster with Haswell E5-2695 v3 processors for compute (Nut1, Nut2, Nut3, Nut4)
- ESXi 6.0 and VMware Horizon View 6.1.0
- A separate R720 rack server for management
- 2 x NVidia Graphic cards K2 (4 GPU processors) per compute node
- Windows 8.1 64-bit clients with the following configuration

Operating System	vCPU	Memory	Disk	Network	Software and Applications
Windows 8.1 Enterprise 64-bit	2	4 GB	80 GB	VmxNet3 and 10GB network	– McAfee VirusScan 8.8 – NVidia driver 347.52 – SpecWPC v.1.2 – VMware View Direct Plug 6.1.0.2509221 – VMware Agent 6.1.0.2509441 – VMTools 9.10.2476743

6.6.1 Client VM Pool

The client VMs were stored on the Nutanix compute hosts. During creation of the pool Client VMs were distributed evenly over 4 compute hosts per the boundaries of the vGPU profiles (32 per host max).

```
   1  GRID K2             On   | 0000:07:00.0     Off |                  Off |
N/A   37C    P8    27W / 117W |   3432MiB /  4095MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
   2  GRID K2             On   | 0000:84:00.0     Off |                  Off |
N/A   39C    P8    29W / 117W |   3434MiB /  4095MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+
   3  GRID K2             On   | 0000:85:00.0     Off |                  Off |
N/A   36C    P8    27W / 117W |   3438MiB /  4095MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
 Processes:                                                       GPU Memory |
  GPU       PID  Type  Process name                               Usage      |
=============================================================================|
    0     86554  C+G   kbgxnutVM7_1                                   416MiB |
    0    593117  C+G   kbgxnutVM7_89                                  416MiB |
    0    593992  C+G   kbgxnutVM7_75                                  416MiB |
    0    593994  C+G   kbgxnutVM7_73                                  416MiB |
    0    596615  C+G   kbgxnutVM7_50                                  416MiB |
    0    600608  C+G   kbgxnutVM7_17                                  416MiB |
    0    657585  C+G   kbgxnutVM7_2                                   416MiB |
    0    657992  C+G   kbgxnutVM7_40                                  416MiB |
    1    152425  C+G   kbgxnutVM7_47                                  416MiB |
    1    593118  C+G   kbgxnutVM7_87                                  416MiB |
    1    593993  C+G   kbgxnutVM7_80                                  416MiB |
    1    595613  C+G   kbgxnutVM7_62                                  416MiB |
    1    595616  C+G   kbgxnutVM7_61                                  416MiB |
    1    598020  C+G   kbgxnutVM7_32                                  416MiB |
    1    657697  C+G   kbgxnutVM7_35                                  416MiB |
    1    658083  C+G   kbgxnutVM7_54                                  416MiB |
    2    593111  C+G   kbgxnutVM7_88                                  416MiB |
    2    593125  C+G   kbgxnutVM7_95                                  416MiB |
    2    593127  C+G   kbgxnutVM7_96                                  416MiB |
    2    595614  C+G   kbgxnutVM7_59                                  416MiB |
    2    596616  C+G   kbgxnutVM7_51                                  416MiB |
    2    598016  C+G   kbgxnutVM7_3                                   416MiB |
    2    598017  C+G   kbgxnutVM7_38                                  416MiB |
    2    604358  C+G   kbgxnutVM7_12                                  416MiB |
    3    593126  C+G   kbgxnutVM7_99                                  416MiB |
    3    593997  C+G   kbgxnutVM7_76                                  416MiB |
    3    595617  C+G   kbgxnutVM7_68                                  416MiB |
    3    596613  C+G   kbgxnutVM7_53                                  416MiB |
    3    598014  C+G   kbgxnutVM7_31                                  416MiB |
    3    598018  C+G   kbgxnutVM7_43                                  416MiB |
    3    600606  C+G   kbgxnutVM7_23                                  416MiB |
    3    604359  C+G   kbgxnutVM7_124                                 416MiB |
+-----------------------------------------------------------------------------+
root@NTNX-53PFT52-A:/tmp]
```

The figure above shows one of the 4 compute hosts containing 32 Client VMs for K220Q 128 Client VM test.

Client VM pools were used with VMware View Connection server pool settings as follows:

- Automated Desktop Pool
- Floating User Assignment
- View Composer Linked Clones
- Remote Display Protocol : PCoIP
- Allow users to choose protocol : no
- 3D renderer : NVidia Grid vGPU
- Provision all up front
- Redirect disposable files to a non-persistent disk of 4096 MB
- Use : Nutanix Container when asked for datastore
- Storage Acceleration off
- Other options : use native NFS snapshots – no
- Other options: initiate reclamation when unused space on VM exceeds xx GB – no
- Quick prep or sysprep scripts : none

Access to the Client VMs was via Horizon View Client installed on 32 test launchers.

6.6.2 Compute and Management Configuration Specifications

Important to note that this 4-node XC730 cluster was used to test the compute aspects of the vGPU infrastructure only, mgmt was segregated to external infrastructure running on R720s.

Each XC730 Compute host under test:

- ESXi 6 build 2494585
- NVidia vGPU driver 346.68
- Intel Xeon E5-2695 v3 @ 2.3GHz
- DDR4 16 x 16 GB @ 2133 MHZ
- 2x SSD 372GB, 6 Gbps, Intel SSDSC2BA40
- 4 x 1TB, 6 Gbps, ST91000640NS
- Intel X520/2P I350 rNDC – two 10Gb connections
- PERC H730 Mini RAID Controller
- 2 x NVidia K2
- Hyper Thread On
- VT on
- Turbo Mode on

R720 Management (outside of XC cluster):

- ESXi 6 build 2494585
- Intel Xeon E5-2670 @ 2.6GHz
- DDR3 128 GB RAM @ 1600 MHZ
- 14 x 300 GB local storage
- Integrated Broadcom BCM57840 10G/GbE 2+2P [2x1Gb + 2x10Gb]
- PERC H710P RAID Controller
- VMware vCenter 6.0.0.16040
- VMware View Composer 6.1.0.2506641
- VMware Tools 9.10.0.2476743

6.6.3 K2 – Results Summary

Tests	Hyper-visor	vGPU Profile	Workload	Density Per Cluster [resolution]	Avg CPU %
Test 1	ESXi 6.0	K220Q	sw-03	128 @ [1920x1080]	89
Test 2	ESXi 6.0	K240Q	sw-03	64 @ [1920x1080]	60

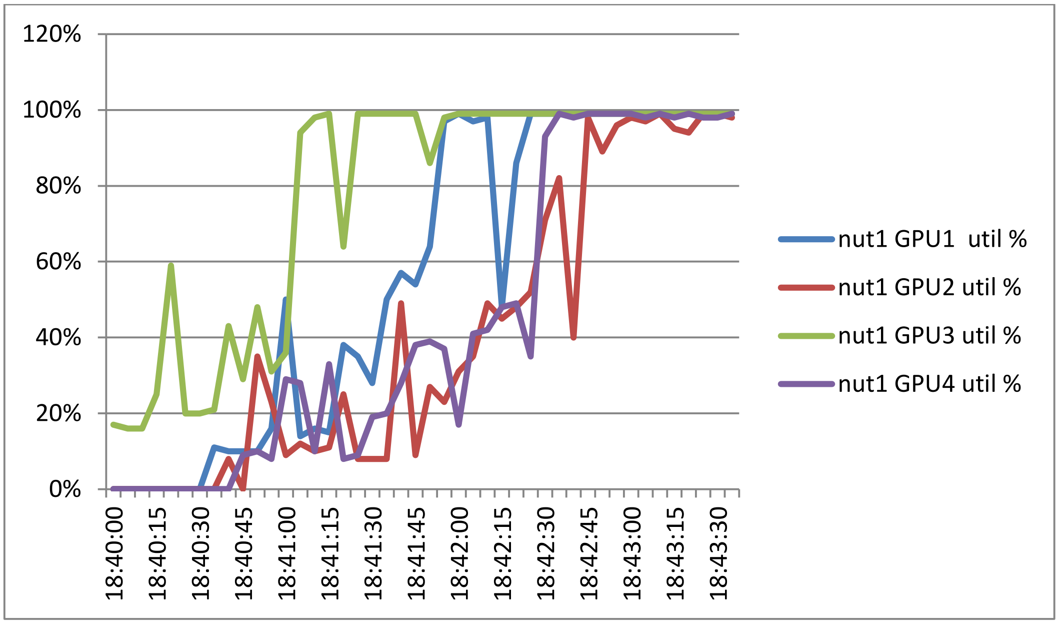
Tests	Avg Memory Active GB	Avg Memory Consumed	Avg GPU	Avg GPU Memory	Avg Net MB/s /User	I/O per user
Test 1	51	160 GB	97 %	18 %	3.073	9.1
Test 2	31	92 GB	74 %	25 %	3.939	11.7

Sw-03 : Specview Perf 12 – SPECwpc v1.2 : sw03 = medium graphics load
Average CPU % : from vSphere Performance data
Average Memory Active GB : from vSphere Performance data
Average Memory Consumed GB : from vSphere Performance data
Average GPU % : from compute server command line with nvidia-smi
Average GPU Memory % : from compute server command line with nvidia-smi
Average Net MB/s per User [c] : from vSphere Performance data : (Compute Host Data RX + Compute Host Data TX) : number of users
I/O per user : from Prism Analyzer installed on the Nutanix cluster : [Disk I/O : number of users]

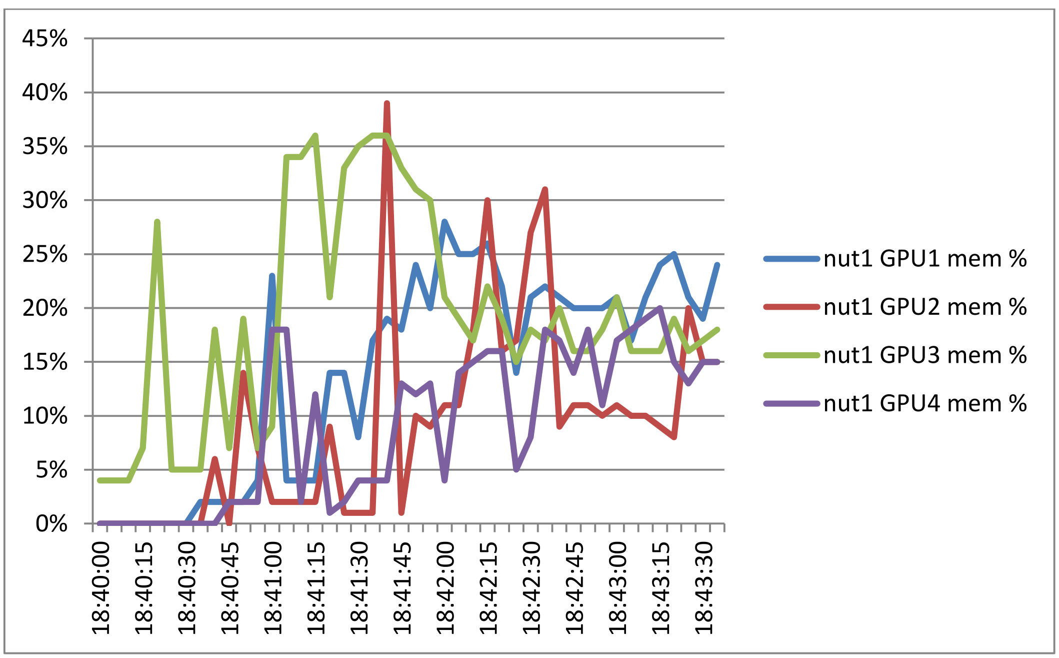
6.6.4 K2 - K220Q – GPU result sets

Test run: SpecView: sw-03
Resolution: 1920 x 1080
Number of Client VMs: 128
Launch Window : 400 sec. Shorter launch windows will result in the GPUs reaching maximum close to simultaneously.

GPU Load from Compute Server [nvidia-smi]



Compute Server GPU Memory Utilization



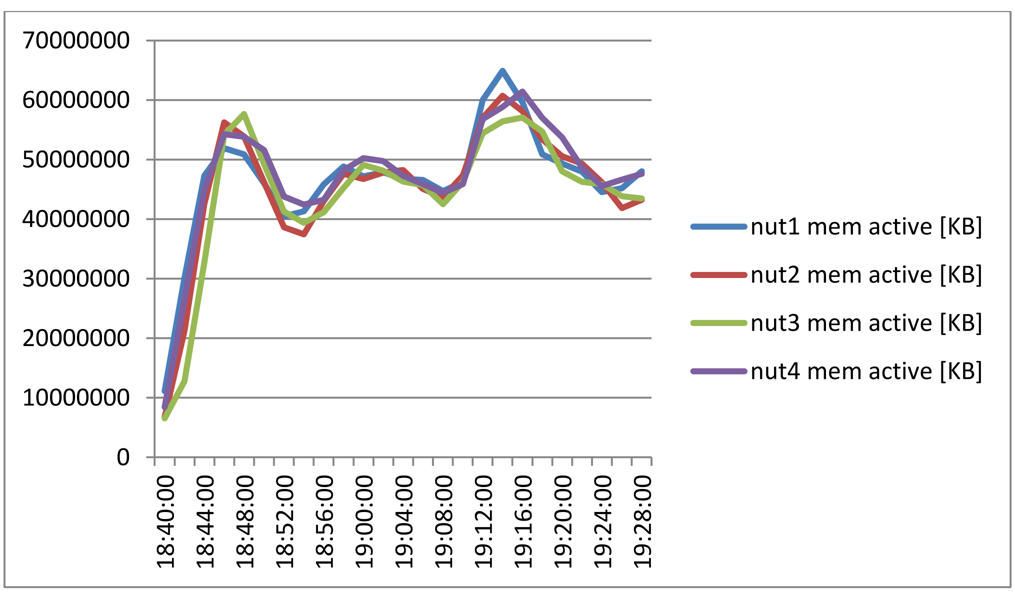
6.6.5 K2 - K220Q – Compute Host Results

Test run: SpecView: sw-03
Resolution: 1920 x 1080
Number of Client VMs: 128

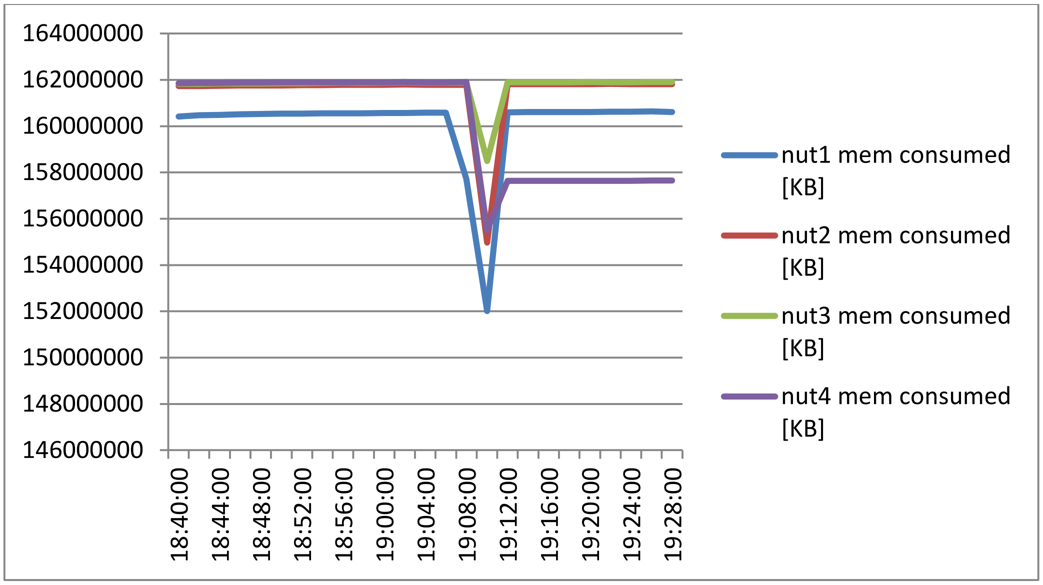
Compute cluster host: CPU

* At point 17 four client VMs/host were intentionally powered off

Compute hosts: Memory Active

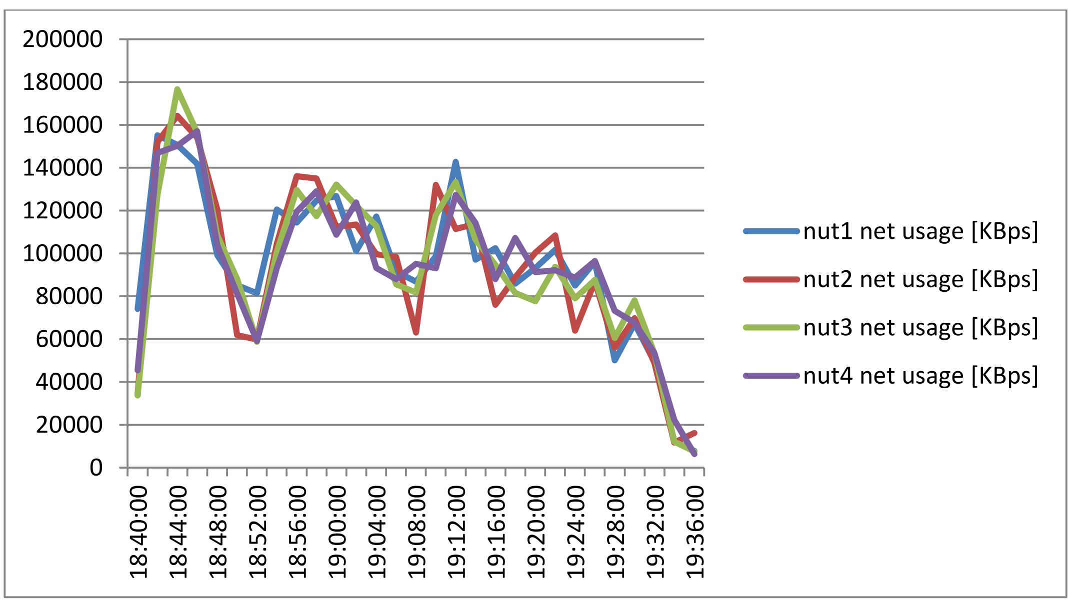


Compute hosts: Memory Consumed

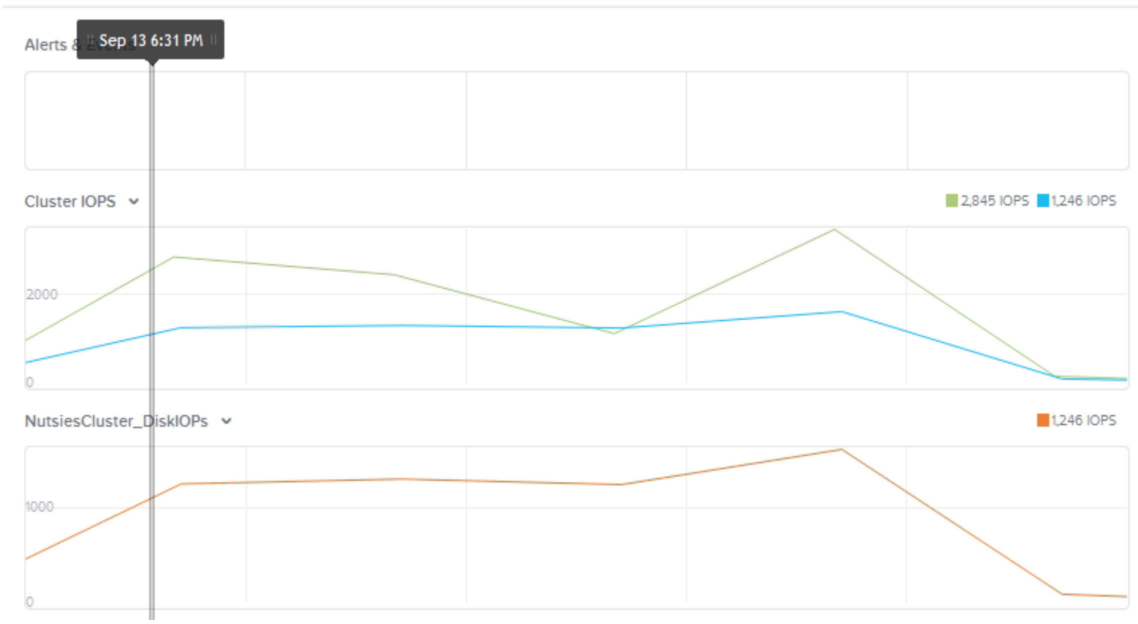


* At point 17 four client VMs/host were intentionally powered off

Compute hosts: Network



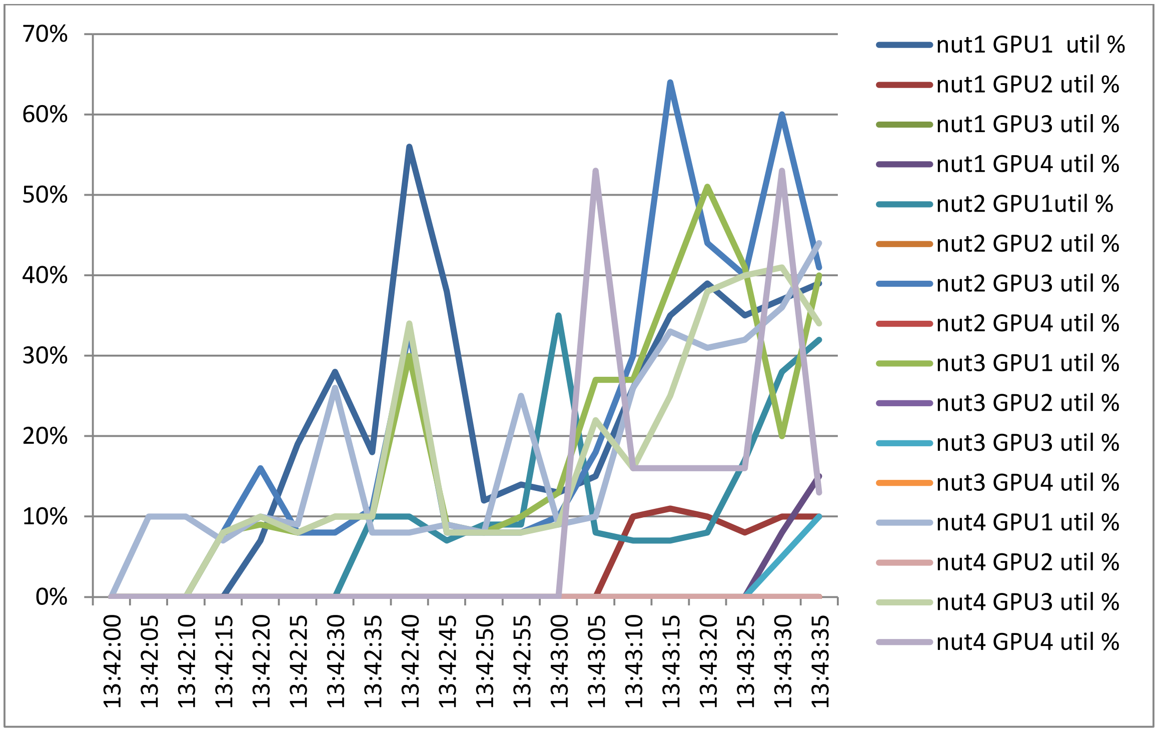
Compute hosts: IOPs



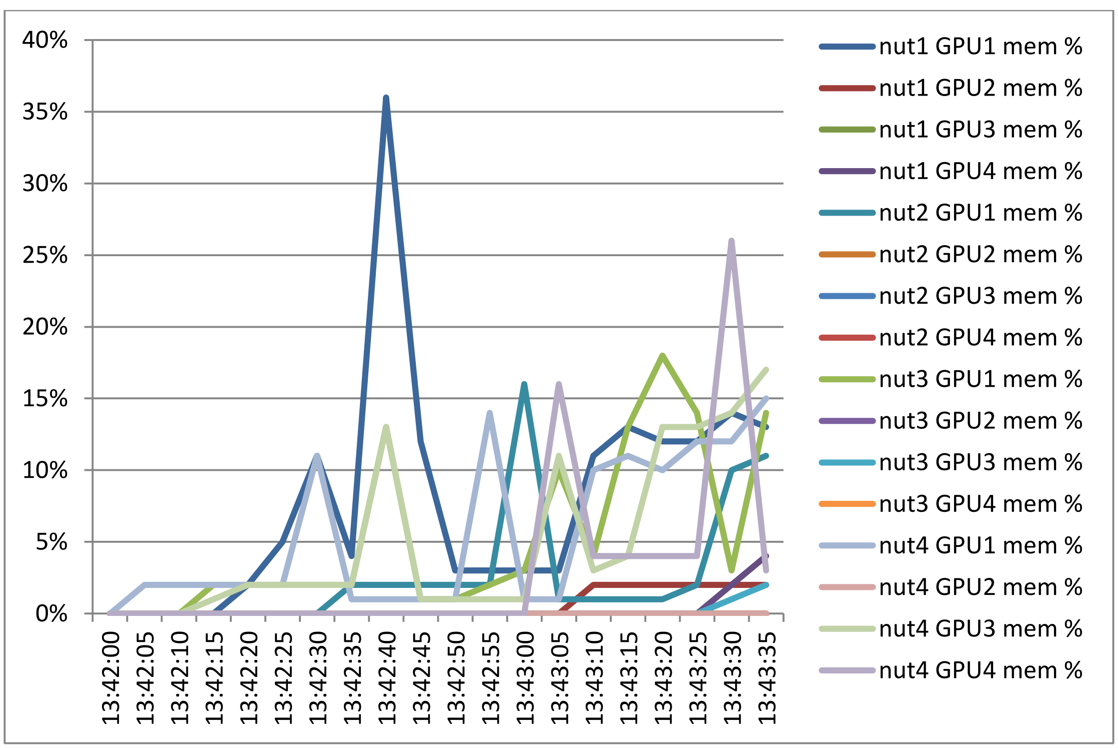
6.6.6 K2 – K240Q – GPU Performance Results

Test run: SpecView: sw 03
Resolution: 1920 x 1080
Number of Client VMs: 64

Compute Cluster GPU Load



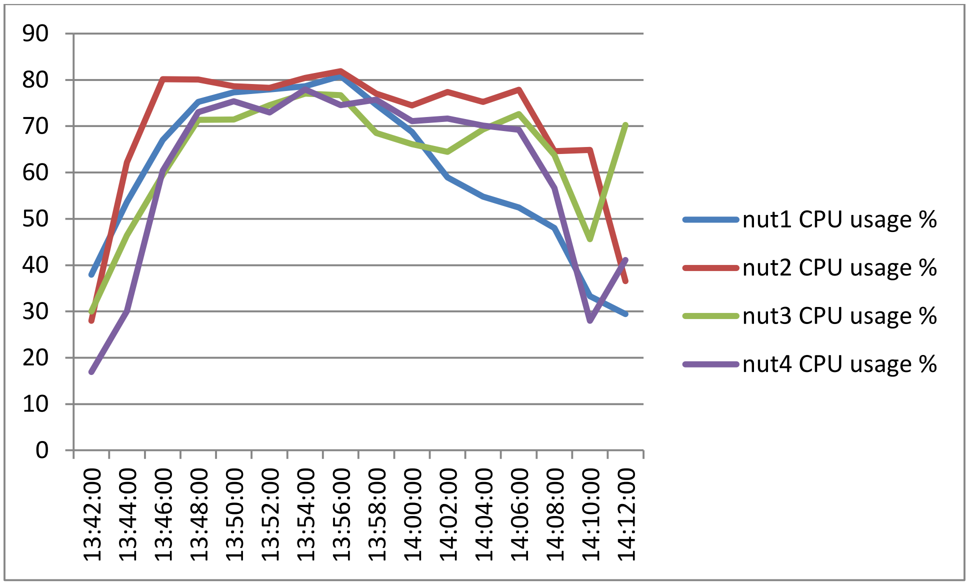
Compute Cluster GPU Memory Utilization



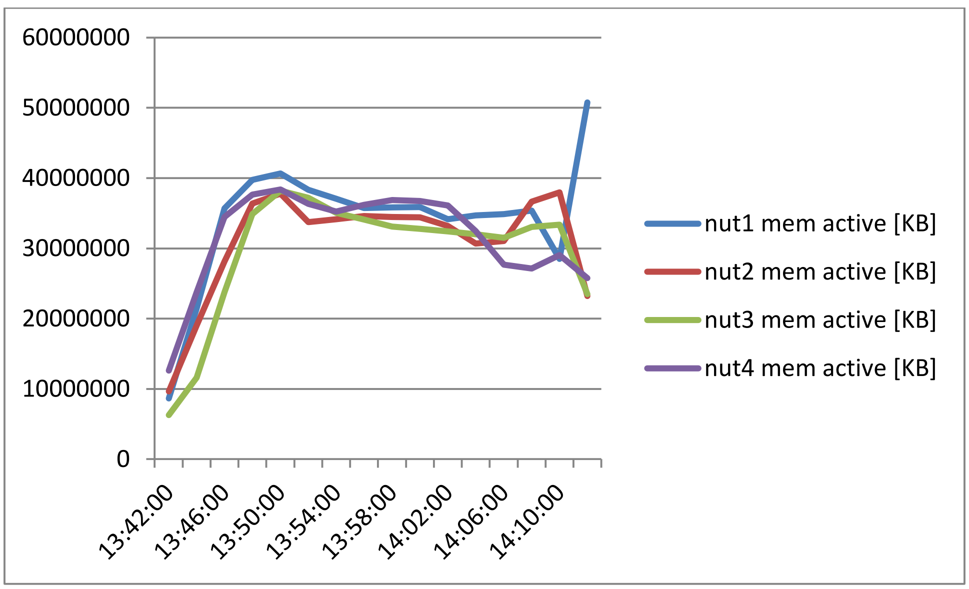
6.6.7 K2 – K240Q – Compute Host Results

Test run: SpecView: sw 03
Resolution: 1920 x 1080
Number of Client VMs: 64

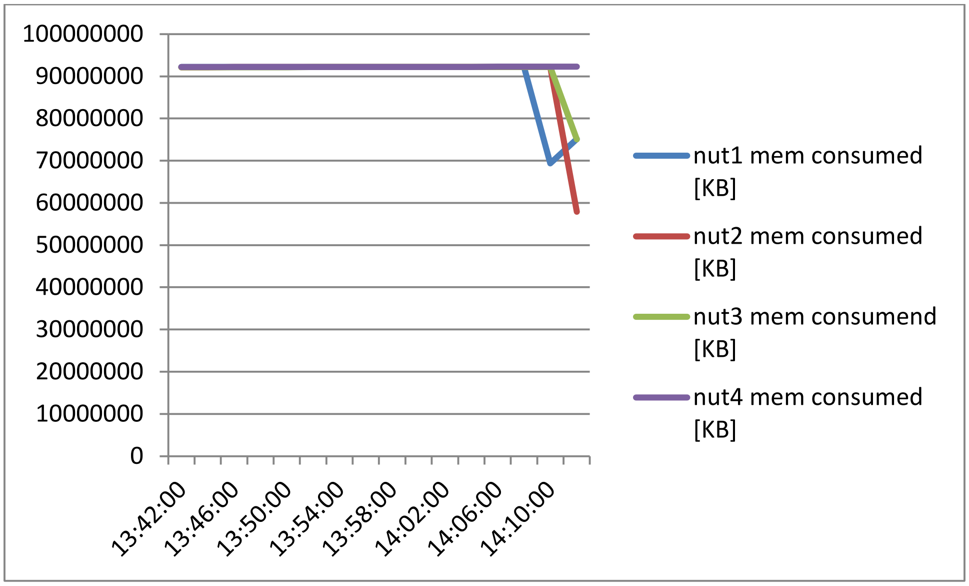
Compute host: CPU



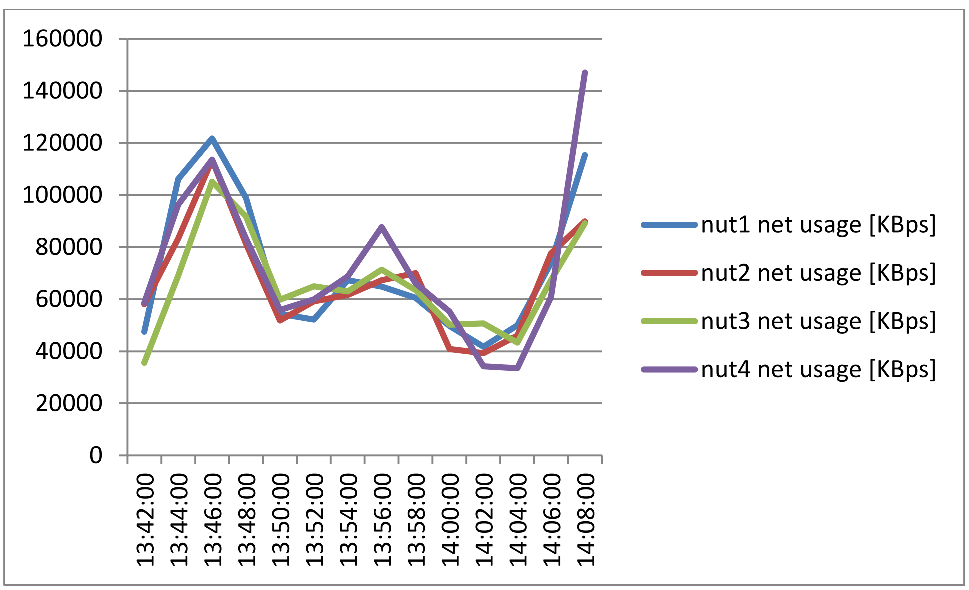
Compute hosts: Memory Active



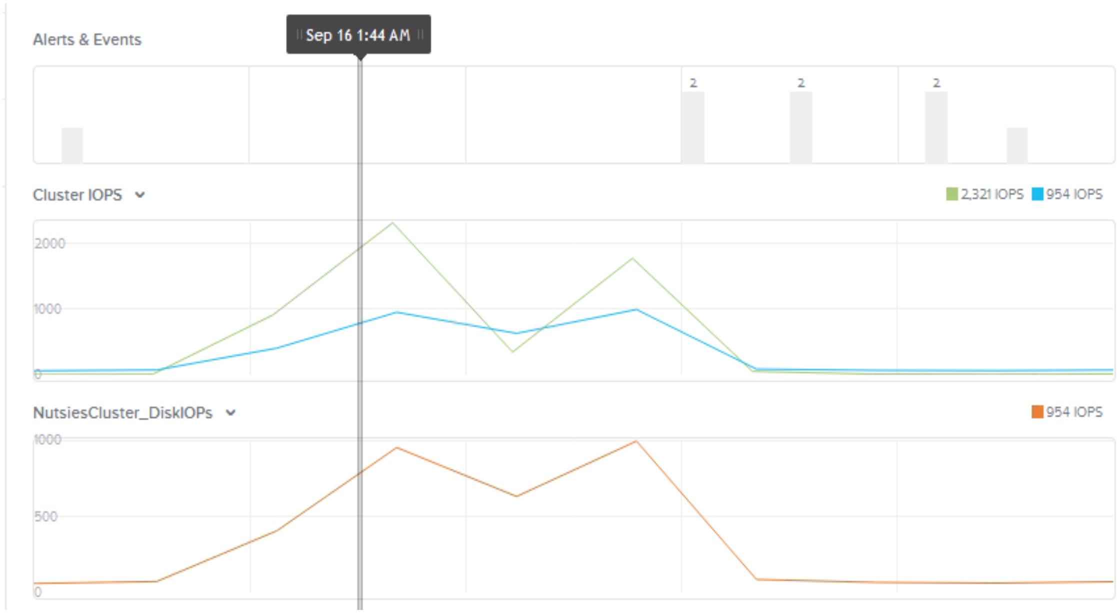
Compute Hosts: Memory Consumed



Compute Hosts: Network



Compute Host Cluster IOPs



Average Cluster IOPs from Nutanix Analyzer: 1267 IOPS

Acknowledgements

Thank you to the Nutanix Technical Marketing team for the detail presented in section 2.2 of this document.

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