Dell Wyse Datacenter for VMware Horizon View SAN-less Blade Reference Architecture

A Reference Architecture for the design, configuration and implementation of VMware Horizon View in a blade server environment without a SAN.

Dell Wyse Solutions Engineering
June 2014
## Revisions

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 2014</td>
<td>Initial release v.6.5</td>
</tr>
</tbody>
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Purpose and scope

The purpose of this document is to describe the architecture design, configuration and implementation considerations for key components required to deliver virtual desktops via the Dell Wyse Datacenter for VMware Horizon View using PowerEdge blade servers without default shared storage.

Relative to delivering the virtual desktop environment, the scope of this document is to:

- Define the detailed technical design for the solution
- Define the hardware requirements to support the design
- Define the relevant design constraints
- Define relevant risks, issues, assumptions and concessions (referencing existing where possible)
- Provide a breakdown of the design into key elements such that the reader receives a modular explanation of the design
- Provide solution scaling and component selection guidance
1 Solution architecture overview

1.1 Introduction

The Dell Wyse Datacenter Solution leverages a core set of hardware and software components consisting of 4 primary layers:

- Networking Layer
- Compute Server Layer
- Management Server Layer
- Storage Layer

These components have been integrated and tested to provide the optimal balance of high performance and lowest cost per user. Additionally, the Dell Wyse Datacenter Solution includes an approved extended list of optional components in the same categories. These components give IT departments the flexibility to custom tailor the solution for environments with unique virtual desktop infrastructure (VDI) feature, scale or performance needs. The Dell Wyse Datacenter stack is designed to be a cost effective starting point for IT departments looking to migrate to a fully virtualized desktop environment slowly. This approach allows you to grow the investment and commitment as needed or as your IT staff becomes more comfortable with VDI technologies.

1.2 Physical architecture overview

The core Dell Wyse Datacenter architecture consists of two models: Local Tier 1 and Shared Tier 1. Tier 1 in the Dell Wyse Datacenter context defines from which disk source the VDI sessions execute. Local Tier 1 includes rack or blade servers with solid state drives (SSDs) while Shared Tier 1 can include rack or blade servers due to the usage of shared Tier 1 storage. Tier 2 storage is present in both solution architectures and, while having a reduced performance requirement, is utilized for user profile/data and Management virtual machine (VM) execution. Management VM execution occurs using Tier 2 storage for all solution models. Dell Wyse Datacenter is a 100% virtualized solution architecture.
1.3 Dell Wyse Datacenter SAN-less – solution layers

The SAN-less solution uses the PowerEdge M1000e blade chassis including a pair of high-performance PowerEdge M I/O Aggregator (IOA) switches in the A fabric. The IOAs handle all east-west traffic between the blades within the chassis without having to go to the top of rack (ToR) switch. This integrated switch connects two 1Gb NICs to the A fabric of all blade hosts in the chassis. ToR switching is optional and best satisfied using a high performance Force10 switch.

In the Local Tier 1 architecture for blades, there is no need for a ToR switch unless iSCSI is present to provide management layer high availability. The A fabric IOA switches connect directly to the core or distribution network layer. Management and compute servers connect to all VLANs in this model via a single vSwitch.

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In the Local Tier 1 architecture for blades, there is no need for a ToR switch unless iSCSI is present to provide management layer high availability. The A fabric IOA switches connect directly to the core or distribution network layer. Management and compute servers connect to all VLANs in this model via a single vSwitch.

The compute layer consists of the server resources responsible for hosting the Horizon View user sessions, hosted via the VMware vSphere hypervisor.

VDI management components are dedicated to their own layer so as to not negatively impact the user sessions running in the compute layer. This physical separation of resources provides clean, linear and predictable scaling without the need to reconfigure or move resources within the solution as you grow. The management layer will host all the VMs necessary to support the VDI infrastructure.
1.4 Local Tier 1 for blade servers

The SAN-less architecture shown below makes use of VMware Horizon inked clone technology to provision the desktop pool from a master image residing locally on each compute host. Each blade is outfitted with a pair of high performance 800GB SSDs configured in RAID-1 to house either desktop or management VMs. This solution is available with as few as two blades; one management and one compute, scaling to support thousands of users. Aside from the local SSDs, the blade hardware configuration is in line with the standard Dell Wyse Datacenter solution recommendations.
1.4.1 Management layer high availability

The Local Tier 1 solution model for blade servers provides a high-performance configuration that does not require shared storage but Tier 2 is added to provide high availability (HA) to the management layer infrastructure. User VDI sessions are hosted locally on SSDs in each blade server using VMware Horizon linked clones for desktop delivery. Only a pair of PowerEdge M I/O Aggregator switches is required in the A fabric. The B fabric, ToR iSCSI switches and Tier 2 storage are optional.

1.4.2 Network architecture

In the Local Tier 1 architecture for blades, there is no need for a ToR switch unless iSCSI is present to support HA. The A fabric IOA switches can connect directly to the core or distribution network layer. Both management and compute servers connect to all VLANs in this model via a single vSwitch. The diagram to the right illustrates the server NIC to chassis switch connections, vSwitch assignments, as well as logical VLAN flow in relation to the core switch.
1.4.3 Cabling for high availability

The following diagram depicts the Local Tier 1 blade solution including optional components for HA. The A fabric, B fabric and ToR switches are stacked, respectively.

![Diagram of Cabling for High Availability]

1.4.4 Scaling guidance

<table>
<thead>
<tr>
<th>User Scale</th>
<th>Blade LAN (A Fabric)</th>
<th>Blade iSCSI (B Fabric)</th>
<th>ToR 10Gb iSCSI</th>
<th>EQL Tier 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1000 (no HA)</td>
<td>IOA</td>
<td>IOA</td>
<td>S4810</td>
<td>PS4110E</td>
</tr>
<tr>
<td>1-1000 (HA)</td>
<td>IOA</td>
<td>IOA</td>
<td>S4810</td>
<td>PS6210E</td>
</tr>
<tr>
<td>1-6000 (HA)</td>
<td>IOA</td>
<td>IOA</td>
<td>S4810</td>
<td>PS6210E</td>
</tr>
<tr>
<td>6000+</td>
<td>IOA</td>
<td>IOA</td>
<td>S4810</td>
<td>PS6510E</td>
</tr>
</tbody>
</table>
2  Hardware components

2.1  Network – PowerEdge M I/O Aggregator

<table>
<thead>
<tr>
<th>Model</th>
<th>Features</th>
<th>Options</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>PowerEdge M I/O</td>
<td>• Up to 32 x 10Gb ports + 4 external SFP+</td>
<td>2-port QSFP+ module in 4x10Gb mode</td>
<td>Blade switch for iSCSI in Shared Tier 1 blade solution, LAN + iSCSI in Local Tier 1 blade solution.</td>
</tr>
<tr>
<td>Aggregator</td>
<td>• 2 x line rate fixed QSFP+ ports</td>
<td>4-port SFP+ 10Gb module</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Up to 2 FlexIO modules</td>
<td>4-port 10GBASE-T copper module (1 per IOA)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stack up to 2 IOAs using QSFP+ ports</td>
<td></td>
</tr>
</tbody>
</table>

Guidance:

- Onboard QSFP+ ports are used for stacking a pair of IOAs within a single chassis.
- An additional SFP+ or 10GBT FlexIO module is added to provide uplinks.

2.2 Servers

2.2.1 PowerEdge M1000e Blade Enclosure
A fully modular blade enclosure optimized for Dell blade servers, this 10U enclosure holds up to 8 full-height, 16 half-height or 32 quarter-height blade servers. Dynamic power management allows for predefined power limits to individual blades; real-time reporting for enclosure and blade power consumption; real-time thermal monitoring; secure SSL and command line interfaces; front control panel with interactive LCD for module setup, info and troubleshooting. With unrivaled power efficiency and I/O throughput for performance combined with scalability and flexibility, the PowerEdge M1000e blade enclosure is capable of meeting blade server needs for multiple generations.

For more information please visit: http://www.dell.com/us/business/p/poweredge-m1000e/pd

2.2.2 PowerEdge M620
The PowerEdge M620 is a feature-rich dual-processor, half-height blade server which offers a blend of density, performance, efficiency and scalability. The M620 offers remarkable computational density, scaling up to 24 cores, 2 socket Intel Xeon processors and 24 DIMMs (768GB RAM) of DDR3 memory in a very compact form factor.

For more information please visit: http://www.dell.com/us/business/p/poweredge-m620/pd
2.3 Cloud client endpoint devices
The following Wyse Cloud Clients are the recommended choices for this solution.

2.3.1 Dell Wyse P25
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.

2.3.2 Dell Wyse D10DP
The Dell Wyse D10DP 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.

2.3.3 Dell Wyse P45
Uncompromising computing with the benefits of secure, centralized management. The Dell Wyse P45 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.
2.3.4 Dell Wyse Z50D

Designed for power users, the Dell Wyse X50D is the highest performing thin client on the market. Highly secure and ultra-powerful, the X50D 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, HD video and 3D modelling.

2.3.5 Dell Wyse Z90D

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.

2.3.6 Dell Chromebook 11

With its slim design and high performance, the Dell Chromebook 11 features a 4th Generation Intel Celeron 2955U processor, 11.6-inch screen, up to 10-hours of battery life and 16GB embedded Solid State Drive which allow it to book in seconds. The Dell Chromebook 11 is available in two models with either 2GB or 4GB of internal DDR3 RAM. This provides options for the education ecosystem, allowing students, teachers and administrators to access, create and collaborate throughout the day at a price point that makes widespread student computing initiatives affordable. The Dell Chromebook 11 features an 11.6-inch, edge-to-edge glass screen that produces exceptional viewing clarity at a maximum resolution of 1366x768 and is powered by Intel HD Graphics. The high-performing display coupled with a front-facing 720p webcam creates exciting opportunities for collaborative learning. The Dell Chromebook 11 is less than one inch in height and starts at 2.9lbs, making it highly portable. With two USB 3.0 ports, Bluetooth 4.0 and an HDMI port, end users have endless possibilities for collaborating, creating, consuming and displaying content. With battery life of up to 10-hours, the Chromebook is capable of powering end users throughout the day. Finally, with a fully compliant HTML5 browser, the Dell Chromebook11 is an excellent choice as an endpoint to a HTML5/BLAST connect Horizon View VDI desktop.
3 Software components

3.1 VMware Horizon View

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.
3.2 VDI hypervisor platform

3.2.1 VMware vSphere 5.5

VMware vSphere 5.5 (currently version 5.5 U1) is a virtualization platform used for building VDI and cloud infrastructures. vSphere 5 represents a migration from the ESX architecture to the ESXi architecture.

VMware vSphere 5.5 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 client and the vSphere web client.

Throughout the Dell Wyse Datacenter solution, all VMware and Microsoft best practices and prerequisites were adhered to (NTP, DNS, Active Directory, etc.). The vCenter 5 VM used in the solution was a single Windows Server 2012 R2 VM (Check for current Windows Server OS compatibility at: http://www.vmware.com/resources/compatibility), residing on a host in the Management layer. SQL server is a core component of vCenter and was hosted on another VM also residing in the Management tier. All additional Horizon View components should be installed in a distributed architecture with one role per VM.

For more information on VMware vSphere, visit http://www.vmware.com/products/vsphere
4 Solution architecture

4.1 Compute server
In the Local Tier 1 model for blades, VDI sessions execute on local high-performance SSDs on each compute host. vSphere is used as the hypervisor in this solution due to its ability to run from and integrated SD memory card thereby freeing up the SSDs for VDI execution. In this model, shared storage is not required for Tier 2 unless management host-level HA is required. All management and desktop VMs are hosted locally on their respective blade servers. The recommended provisioning method is linked clone with non-persistent desktops.

<table>
<thead>
<tr>
<th>Local Tier 1 Compute Host PowerEdge M620</th>
<th>Local Tier 1 Management Host PowerEdge M620</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x Intel Xeon E5-2690v2 Processor (3GHz)</td>
<td>2 x Intel Xeon E5-2670v2 Processor (2.5GHz)</td>
</tr>
<tr>
<td>256GB Memory (16 x 16GB DIMMs @ 1600Mhz)</td>
<td>96GB Memory (6 x 16GB DIMMs @ 1600Mhz)</td>
</tr>
<tr>
<td>VMware vSphere on dual internal 2GB SD</td>
<td>VMware vSphere on dual internal 2GB SD</td>
</tr>
<tr>
<td>Broadcom 57810-k 10Gb DP KR NDC (LAN)</td>
<td>Broadcom 57810-k 10Gb DP KR NDC (iSCSI HA)</td>
</tr>
<tr>
<td>iDRAC7 Enterprise w/ vFlash, 8GB SD</td>
<td>iDRAC7 Enterprise w/ vFlash, 8GB SD</td>
</tr>
</tbody>
</table>

4.2 Management server infrastructure
The Management server role requirements 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. Present Tier 2 volumes with a special purpose (called out above) in the format specified below:

<table>
<thead>
<tr>
<th>Role</th>
<th>vCPU</th>
<th>RAM (GB)</th>
<th>NIC</th>
<th>OS + Data vDisk (GB)</th>
<th>Tier 2 Volume (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection Server</td>
<td>4</td>
<td>8</td>
<td>1</td>
<td>40 + 5</td>
<td>-</td>
</tr>
<tr>
<td>Composer</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>40 + 5</td>
<td>-</td>
</tr>
<tr>
<td>vCenter</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td>40 + 5</td>
<td>50 (VMDK/VHDX)</td>
</tr>
<tr>
<td>SQL Server</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td>40 + 5</td>
<td>200 (VMDK/VHDX)</td>
</tr>
<tr>
<td>Totals</td>
<td>9</td>
<td>26</td>
<td>4</td>
<td>180</td>
<td>250</td>
</tr>
</tbody>
</table>

4.2.1 SQL databases
The VMware databases will be hosted by a single dedicated SQL 2008 R2 Server VM (check DB compatibility at: [http://partnerweb.vmware.com/comp_guide2/sim/interop_matrix.php](http://partnerweb.vmware.com/comp_guide2/sim/interop_matrix.php)) 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 will be required for:

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

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

The EqualLogic PS series arrays utilize a default RAID stripe size of 64K. To provide optimal performance, configure disk partitions to begin from a sector boundary divisible by 64K.

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).

### 4.2.2 DNS

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

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

### 4.2.3 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 would be 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 |

### 4.3 Virtual networking

The network configuration in this model will vary slightly between the Compute and Management hosts. The Management VMs are hosted on local storage and optionally on shared Tier 2 if Live Migration is a requirement. The following outlines the VLAN requirements for the Compute and Management hosts in this solution model:
- Compute hosts (Local Tier 1)
  - Management VLAN: Configured for hypervisor infrastructure traffic – L3 routed via core switch
  - VDI VLAN: Configured for VDI session traffic – L3 routed via core switch
- Management hosts (Local Tier 1)
  - Management VLAN: Configured for hypervisor Management traffic – L3 routed via core switch
  - Live Migration VLAN: Configured for Live Migration traffic – L2 switched only, trunked from core (HA)
  - iSCSI VLAN: Configured for iSCSI traffic – L2 switched only via ToR switch (HA)
  - VDI Management VLAN: Configured for VDI infrastructure traffic – L3 routed via core switch
- An optional iDRAC VLAN can be configured for all hardware management traffic – L3 routed via core switch

4.3.1 vSphere (Non-HA)

Each Local Tier 1 Compute and Management blade host have a 10Gb dual port LOM in the A Fabric that will flow through 2 x IOA blade interconnects. The B and C Fabrics are left open for optional expansion. Connections should pass through the blade mezzanines and interconnects per the diagram below. Configure the LAN traffic from the chassis interconnects to the ToR switch as a LAG if possible.
4.3.2 vSphere (HA)
Following best practices, iSCSI and LAN traffic is physically separated into discrete Fabrics for the HA design. If management HA is required, the B Fabric is populated with a 10Gb DP NIC connecting through an additional pair of IOA blade interconnects.
4.4 VMware Horizon View communication flow
5  **Solution performance and testing**

5.1  **Load generation and monitoring**

5.1.1  **Login VSI – Login Consultants**
Login VSI is the de-facto industry standard tool for testing VDI environments and server-based computing / terminal services environments. It installs a standard collection of desktop application software (e.g. Microsoft Office, Adobe Acrobat Reader etc.) 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.

5.1.2  **Liquidware Labs Stratusphere UX**
Stratusphere UX was used during each test run to gather data relating to User Experience and desktop performance. Data was gathered at the Host and Virtual Machine layers and reported back to a central server (Stratusphere Hub). The hub was then used to create a series of “Comma Separated Values” (.csv) reports which have then been used to generate graphs and summary tables of key information. In addition the Stratusphere Hub generates a magic quadrant style scatter plot showing the Machine and IO experience of the sessions. The Stratusphere hub was deployed onto the core network therefore its monitoring did not impact the servers being tested. This core network represents an existing customer environment and also includes the following services:

- Active Directory
- DNS
- DHCP
- Anti-Virus

Stratusphere UX calculates the User Experience by monitoring key metrics within the Virtual Desktop environment, the metrics and their thresholds are shown in the following screen shot:
5.1.3 VMware vCenter

VMware vCenter has been 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.

5.2 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.
5.2.1 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 causing poor performance. 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 can be hosted by a specific hardware environment (i.e. combination of server, storage and networking) that forms the basis for this Dell Wyse Datacenter for VMware Horizon View Reference Architecture.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pass / Fail Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical host CPU utilization</td>
<td>85%</td>
</tr>
<tr>
<td>Physical host memory utilization</td>
<td>85%</td>
</tr>
<tr>
<td>Network throughput</td>
<td>85%</td>
</tr>
<tr>
<td>Storage IO latency</td>
<td>20ms</td>
</tr>
</tbody>
</table>

5.2.2 EUE tools information

Good EUE is one of the primary factors in determining the success of a VDI implementation. As a result, a number of vendors have developed toolsets that monitor the environmental parameters that are relevant to EUE. PAAC on Dell Wyse Datacenter solutions uses the Liquidware Labs Stratusphere UX tool to ensure that good EUE is delivered for the density numbers defined in our RAs. More specifically, our PAAC analysis uses a scatter plot provided by Stratusphere UX which presents end-user experience for all load-testing users. Stratusphere UX does this by algorithmically combining relevant parameters in relation to virtual machine experience (e.g. login duration) and virtual desktop IO experience (e.g. disk queue length) to provide a plot that shows end user experience as good, fair or poor using a golden-quadrant type approach.

5.2.3 EUE real user information

To complement the tools-based end user experience information gathered using Stratusphere UX (as described above) and to provide further certainty around the performance of Dell Wyse Datacenter solutions, PAAC on our solutions also involves a user logging into one of the solutions when they are fully loaded (based on the density specified in the relevant RA) and executing user activities that are representative of the user type being tested (e.g. task, knowledge or power user). An example would be a knowledge worker executing a number of appropriate activities in Excel. The purpose of this activity is to verify that the end-user experience is as good as the user would expect on a physical laptop or desktop.

5.2.4 Dell Wyse Datacenter workloads and profiles

It is 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. For our testing, we use three
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 have presented detailed information for these workloads and profiles below; however, it is useful to define the terms “workload” and “profile” as they are used in this document.

- **Profile** – The configuration of the virtual desktop – the number of vCPUs and amount of RAM configured on the desktop (i.e. visible to the user).
- **Workload** – The set of applications used for performance analysis and characterization (PAAC) of Dell Wyse Datacenter solutions (e.g. Microsoft Office applications, PDF reader, Internet Explorer etc.).

### 5.2.5 Dell Wyse Datacenter profiles

The table below presents the profiles used during PAAC of the Dell Wyse Datacenter solutions. These profiles have been carefully selected to provide the optimal level of resources for the most common use cases.

<table>
<thead>
<tr>
<th>Profile Name</th>
<th>vCPUs per VM</th>
<th>Memory per VM</th>
<th>Use Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>1</td>
<td>2 GB</td>
<td>Task worker</td>
</tr>
<tr>
<td>Enhanced</td>
<td>2</td>
<td>3 GB</td>
<td>Knowledge worker</td>
</tr>
<tr>
<td>Professional</td>
<td>2</td>
<td>4 GB</td>
<td>Power user</td>
</tr>
<tr>
<td>Shared Graphics</td>
<td>2 + shared GPU</td>
<td>3 GB</td>
<td>Knowledge worker with high graphics requirements</td>
</tr>
<tr>
<td>Dedicated Graphics</td>
<td>4 + dedicated GPU</td>
<td>32 GB</td>
<td>Workstation-type user producing complex 3D models</td>
</tr>
</tbody>
</table>

### 5.2.6 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 use cases, the workloads are Login VSI workloads. In the case of graphics use cases, the workloads 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.

<table>
<thead>
<tr>
<th>Profile Name</th>
<th>Workload</th>
<th>OS Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>Login VSI Light</td>
<td>Shared</td>
</tr>
<tr>
<td>Enhanced</td>
<td>Login VSI Medium</td>
<td>Shared</td>
</tr>
<tr>
<td>Professional</td>
<td>Login VSI Heavy</td>
<td>Shared + profile virtualization</td>
</tr>
<tr>
<td>Shared Graphics</td>
<td>Fishbowl / eFigures</td>
<td>Shared + profile virtualization</td>
</tr>
<tr>
<td>Dedicated Graphics</td>
<td>eFigures / AutoCAD – SPEC Viewperf</td>
<td>Persistent</td>
</tr>
</tbody>
</table>

With respect to the table above, additional information for each of the workloads is given below. It should be noted that for Login VSI testing, the following login and boot paradigm was used:
- For single-server / single-host testing (typically carried out to determine the virtual desktop capacity of a specific physical server), users were logged in every 30 seconds.
- For multi-host / full solution testing, users were logged in over a period of 1-hour, to replicate the normal login storm in an enterprise environment.
- All desktops were fully booted prior to each login attempt.

For all testing, virtual desktops ran an industry-standard anti-virus solution (McAfee VirusScan Enterprise) in order to replicate a typical customer environment.

### 5.2.7 Login VSI 3 vs. Login VSI 4
PAAC on Dell Wyse Datacenter solutions is currently carried out using Login VSI version 4. However, some previous Dell Wyse Datacenter solutions used Login VSI version 3 for this PAAC work. Login VSI version 3 used a slightly different set of workloads to those used by Login VSI 4 and in order to allow comparison of results obtained using these different Login VSI versions, it is useful to be aware of the information presented in the figure below. This information (for Login VSI medium workload) illustrates higher CPU utilization and lower disk IO for Login VSI 4 (green / upper set of graphs) when compared to Login VSI3 (red / lower set of graphs). The exact variation between these Login VSI versions will vary between environments.

#### 5.2.7.1 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.

#### 5.2.7.2 Login VSI medium workload
The Login VSI medium workload is designed to run on 2 vCPUs 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 4 segments, each consecutive Login VSI user logon will start a different segments. This ensures that all elements in the workload are equally used throughout the test.
- The medium workload opens up to 5 applications simultaneously.
- The keyboard type rate is 160 ms for each character.
- Approximately 2 minutes of idle time is included to simulate real world users.
Each loop will open and use:

- Outlook, browse messages.
- Internet Explorer, browsing 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 reviewed to PDF.
- Excel, a very large randomized sheet is opened.
- PowerPoint, a presentation is reviewed and edited.
- FreeMind, a Java based Mind Mapping application.

5.2.7.3 Login VSI heavy workload

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

- Begins by opening 4 instances of Internet Explorer. These instances stay open throughout the workload loop.
- Begins by opening 2 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 2 minutes.

5.3 Testing and validation

5.3.1 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 4 runs. A pilot run to validate that the infrastructure is functioning and valid data can be captured and 3 subsequent runs allowing correlation of data. Summary of the test results will be 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 will be subjective, it will help provide a better understanding of the end user experience of the desktop sessions, particularly under high load and ensure that the data gathered is reliable.

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 - 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 configured to launch a specific number of sessions at a specified interval specified in seconds.

All test runs were conducted using the Login VSI “Parallel Launch” mode, 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.

5.3.2 Local tier 1 for blades test results

5.3.2.1 Configuration

The purpose of this validation was to investigate the feasibility of providing a VMware Horizon View based VDI solution on Dell M620 blade servers in Dell M1000E chassis that does not require access to an external storage array. All storage requirements are provided by internal solid state disks installed in the M620 blades. This includes both management and compute storage. External access is only required by the solution for client access to the VMware Horizon View VMs and for access to other infrastructure such as Active Directory within the environment.

This validation was performed for VMware Horizon View 6.0 delivering VDI desktops on a single M620 Compute server running vSphere ESXi 5.5. The Compute Host was outfitted with 256 GB RAM (1600 MHz), dual 3.0 GHz Ivy Bridge E5-2690v2 processors, and 2 800 MLC SSD drives in a RAID 1 configuration. The compute host connected to the SSD drives through a Dell H310 PERC controller.

In the solution validated the management host was a separate M620 with 2 * 15K 300GB disks in a RAID 1 configuration connected by a PERC H310. However, for a full solution it is envisaged that there would not be a dedicated management host in the blade chassis. Instead, the management components will run on any of the Compute nodes. Each node is identically configured in the same way as the compute node above. Based on the latencies observed during the Login VSI tests on the compute nodes the solution should scale well to accommodate up to 16 blades. In addition the Virtual Center appliance was deployed with sufficient capacity for up to 20 hosts and 2000 VMs.

The M1000e blade chassis was fitted with a Dell MIO aggregator. This supported the external communication from the chassis for VDI and Active directory access, and provided support for all the internal communication between the various VMs hosted on the blades in the chassis. A simple management configuration was implemented using 4 management VMs only, a vSphere Virtual Center appliance, VMware View Connection Server, and VMware View Composer server and SQL Server 2008 was installed on a separate server to support the Composer database.

- 1 VM, 2 vCPU and 8 GB RAM for View Composer plus 30 GB system disk.
- 1 VM, 2 vCPU and 8 GB RAM for Horizon View Connection Server
- 1 VM, 2 vCPU and 8 GB RAM for Virtual Center Appliance, plus 30GB system disk plus 100GB disk for vCenter database
- 1 VM, 2 vCPU and 8 GB RAM for SQL Server

The Desktop images were built using Windows 8.1 Enterprise and Microsoft Office 2010. Only the Enhanced workload was tested using Windows 8.1 32 bit with 2 vCPUs and 3GB memory per VM.

5.3.2.2 Test results

Validation was performed using Dell Wyse Solutions Engineering standard PAAC testing methodology using LoginVSI 4 load generation tool for VDI benchmarking that simulates production user workloads. Stratusphere UX was not used in this validation since it is not compatible with the desktop OS, Windows 8.1 Enterprise.

Each test run was configured to allow for 15 minutes of steady state operations after the initial session launch and login period, so that all sessions is logged in and active for a significant period of time so that statistics could be measured during steady state to simulate daily operations.

The following table summarizes the steady state test results for the various workloads and configurations. The charts in the sections below show more details about the max values for CPU, memory, IOPS, and Network during the test run.

<table>
<thead>
<tr>
<th>Hypervisor</th>
<th>Provisioning</th>
<th>Workload</th>
<th>Density</th>
<th>Avg CPU %</th>
<th>Avg Mem Usage (GB)</th>
<th>Max IOPs/User during login</th>
<th>Avg IOPs/User steady state</th>
<th>Avg Net KBps/User</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESXi</td>
<td>View Linked Clones</td>
<td>Enhanced</td>
<td>110</td>
<td>85%*</td>
<td>203</td>
<td>16</td>
<td>7.9</td>
<td>300</td>
</tr>
<tr>
<td>ESXi</td>
<td>View Linked Clones</td>
<td>Enhanced 0% preboot</td>
<td>110</td>
<td>90%*</td>
<td>212</td>
<td>9.8</td>
<td>4.7</td>
<td>191</td>
</tr>
</tbody>
</table>

* CPU % for ESXi hosts was adjusted to account for the fact that on Intel E5-2600v2 series processors the ESXi host CPU metrics will exceed the rated 100% for the host if Turbo Boost is enabled (by default). With E5-2690v2 CPUs the rated 100% in vSphere is 60000 MHz usage, while actual usage with TB has been seen to reach 67000 MHz in some cases. The Adjusted CPU % Usage is based on 100% = 66000 MHz usage and is used in all charts for ESX to account for Turbo Boost.

The test runs approached very close to the memory limit for the host even while CPU was safely below limits. ESXi reports however show Active memory usage much lower than consumed with very little memory ballooning in evidence.

Tests were run with Storage Acceleration enabled and also with storage acceleration disabled. From the results below it can be seen that storage acceleration significantly reduces the IOPS but the SSDs are still capable of handling the increased IOPs without Storage Acceleration. The CPU usage when using storage acceleration is marginally higher than without.
Network utilization was very consistent across all tests. User profiles were stored on a file server external to the test environment. This accounts for some extra network utilization. However, even for a fully populated blade with 16 * 110 Standard users the network requirement is 4.1Gbps. The installed Dell IO aggregators provide 10Gbps connectivity to the external environment so provide plenty of capacity. It is also possible to support the personas storage within the chassis.

Disk latency on the SSD disks remained very low, less than 1 milliseconds on all the standard tests. Even during the logon storm when 110 VMs logged on within 7 minutes disk latency remained at 2 milliseconds or less.

An addition test was run against the Enhanced image with only 5 of the desktops prebooted. It is interesting to note that the results are almost identical to the Enhanced test with all desktops powered on. Additionally, the SSD disk latency stayed at 0 ms for the duration of the test.

The SSD volumes provided enough space including the ESXi swap file for all the VMs in for 170 VMs. With the VMs powered off the space usage was as follows. The SSDs also hosted the Windows 32 bit and 64 images required to create the VMware View linked clones

When all the VMs are powered on the free space available was 427GB as follows:

<table>
<thead>
<tr>
<th>Location:</th>
<th>ds://vmfs/volumes/52fce207-d82e9ff...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>VMFS</td>
</tr>
<tr>
<td>Number of Hosts Connected:</td>
<td>1</td>
</tr>
<tr>
<td>Virtual Machines and Templates:</td>
<td>113</td>
</tr>
</tbody>
</table>

The SQL Express data file usage was 175MB for View Composer and View Events databases. Adding a further 15 hosts should not increase this to more than 2.75GB so there is room for expansion of the database as further hosts and VMs are added. SQL Express can be used for this solution also thereby reducing the number of Windows Server VMs required. Space usage on the Management Data store was as follows. This also includes space used by Windows 8.1 32 bit and 64 bit templates to provision the View Desktop VMs. This represents the space required for a fully populate M1000E chassis.

The SQL Express data file usage was 175MB for View Composer and View Events databases. Adding a further 15 hosts should not increase this to more than 2.75GB so there is room for expansion of the database as further hosts and VMs are added. SQL Express can be used for this solution also thereby reducing the number of Windows Server VMs required. Space usage on the Management Data store was as follows. This also includes space used by Windows 8.1 32 bit and 64 bit templates to provision the View Desktop VMs. This represents the space required for a fully populate M1000E chassis.
Some further tests were also performed to investigate the capability of the local SSD volumes within the VDI solutions:

- Generate maximum IOPs throughput using IOMETER on a 20 GB disk attached to a Windows 8.1 VM
- Add extra IOPS (22) within each VSI session for a standard Login VSI test to produce a total of 8000 IOPs on the host during the VSI test. Measure the effect on the latency of the SSD volume
- Perform a logon storm with 110 Enhanced VSI sessions logging on within a 7 minute interval instead of sessions logging on at 30 second intervals. Measure the effect of the increased logon rate on the SSD volumes

The results of each of these tests are discussed in later sections of this document.
5.3.2.3 Horizon View linked clone Enhanced User workload with storage acceleration

The following graphs display CPU, memory, local disk IOPs and network results.

![Graphs showing CPU, memory, IOPS, and network usage for 110 Enhanced Horizon Users]
5.3.2.4 Horizon View linked clone Enhanced User workload without storage acceleration

The following graphs display CPU, memory, local disk IOPs and network results.

5.3.2.5 IOMeter test against SSD drives

These graphs show IOMeter results against the SSD drives using the following IOMeter profile. This was performed on a single VM on the compute host using a 20GB disk configured on the SSD volume. The test was run to gather information that would indicate the overall capability of the SSD volume when hosting VDI VMs. The access specifications were configured and proposed by Jim Moyle of Atlantis at the following location http://blog.atlantiscomputing.com/2013/08/how-to-use-iometer-to-simulate-a-desktop-workload.
It can be seen that at 17000 IOPs with 80% write the latency remains at approx. 1 millisecond. While IOMeter test scenarios are very subjective and it is arguable whether the test specification used above truly represents a VDI workload, it does represent a reasonable approximation and the result of 17000 IOPs available on the SSD volume does indicate that it is possible for the solution to support much more IO intensive workloads as indicated in the following graph:

<table>
<thead>
<tr>
<th>Number of Desktops Per Server</th>
<th>Approximate Max IOPS Per Desktop</th>
</tr>
</thead>
<tbody>
<tr>
<td>170 Standard</td>
<td>100</td>
</tr>
<tr>
<td>110 Enhanced</td>
<td>150</td>
</tr>
<tr>
<td>90 Premium</td>
<td>180</td>
</tr>
</tbody>
</table>

5.3.2.6 Horizon View linked clone Enhanced User workload + IOPs generated by IOMeter

The login script launched an automated IOMeter workload in each VDI session to generate extra IOPs within the session. This generated sustained IOPs of approximately 6000. As can be seen from the graphs above the latency of the local tier 1 storage on the SSD volumes did not rise above 2 milliseconds which is well within the bounds that are considered appropriate for VDI performance (i.e. < 20ms).
5.3.2.7 Standard User workload logon storm

During the logon period of 7 minutes the Read and Write latency on the SSD volume rose to 2 milliseconds but quickly dropped to 0 once the sessions reached steady state. The shortened logon interval produced a peak CPU of nearly 100% usage but this dropped off once the steady state was reached.

About the authors

Cormac Woods is a Sr. Solution Engineer in the Dell Wyse Solutions Engineering Solutions Group at Dell building, testing, validating, and optimizing enterprise VDI stacks.

Gus Chavira is the Senior Principal Engineering Architect for VMware Horizon based solutions at Dell. Gus has extensive experience and expertise on the VMware solutions software stacks as well as in Enterprise virtualization, storage and enterprise data center design. Gus has worked in capacities of Sys Admin, DBA, Network and Storage Admin, Virtualization Practice Architect, Enterprise and Solutions Architect. In addition, Gus carries a B.S. in Computer Science

Peter Fine is the Senior Principal Engineering Architect for VDI-based solutions at Dell. Peter has extensive experience and expertise on the broader Microsoft, Citrix and VMware solutions software stacks as well as in enterprise virtualization, storage, networking and enterprise data center design.

Andrew McDaniel is the Solutions Development Manager for VMware solutions at Dell, managing the development and delivery of enterprise-class desktop virtualization solutions based on Dell Data center components and core virtualization platforms.

David Hulama is a Senior Technical Marketing Advisor for VMware Horizon View solutions at Dell. David has a broad technical background in a variety of technical areas and expertise in enterprise-class virtualization solutions.