

# Dell EMC Unity: 3,000 VMware Horizon Linked Clone VDI Users

All-flash arrays

## Abstract

This document provides a reference architecture for running 3,000 VMware® Horizon® linked clone VDI users on Dell EMC™ Unity 680F storage.

November 2019

## Revisions

Date	Description
June 2019	Initial release
November 2019	vVols branding update

## Acknowledgements

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## Executive summary

The Dell EMC™ Unity 680F array makes an excellent platform for VDI workloads. With its unified block and file design, it can provide CIFS/NFS file storage for user data and profiles along with high-performance block storage. This can simplify the deployment of VDI environments.

This paper shows the performance of a Dell EMC Unity 680F array running a standardized VDI workload. The workload used was designed to simulate 3,000 knowledge worker users as defined by Login VSI™.

The Dell EMC Unity 680F array comes standard with support for block and file, point-in-time snapshots, local and remote data replication, built-in encryption, and deep integrations with VMware and Microsoft.

## Audience

This document is intended for Dell EMC Unity administrators, virtualization users, architects, partners, and anyone responsible for configuring Dell EMC Unity storage systems. Some familiarity with Dell EMC unified storage systems is assumed.

We welcome your feedback along with any recommendations for improving this document. Send comments to [StorageSolutionsFeedback@dell.com](mailto:StorageSolutionsFeedback@dell.com).

# 1 Storage configuration

Dell EMC Unity arrays are virtually provisioned, flash-optimized storage systems designed for ease of use. This paper covers an all-flash array model. This section provides foundational array technologies that support the application-specific sections that follow. Additional information for this section can be found in the [Dell EMC Unity: Best Practices Guide](#).

## 1.1 Storage pools

As of Dell EMC Unity OE version 4.2, Dell EMC Unity supports two different types of storage pools on all-flash storage systems: traditional pools and dynamic pools. Traditional pools apply RAID protection to discrete groups of drives within the storage pool. Dynamic pools apply RAID to groups of drive extents from drives within the pool and allow for greater flexibility in managing and expanding the pool.

In general, it is recommended to use a small number of storage pools within Dell EMC Unity to reduce complexity and increase flexibility. However, it may be appropriate to configure additional storage pools in the following instances:

- Separate workloads with different I/O profiles
- Dedicate resources to meet specific performance goals
- Separate resources for multi-tenancy
- Create smaller failure domains

Additional information can be found in the [Dell EMC Unity: Dynamic Pools](#) white paper.

### 1.1.1 Storage pool capacity

Storage pool capacity is used for multiple purposes:

- Store all data written into storage objects — LUNs, file systems, datastores, and VMware® vSphere® Virtual Volumes™ (vVols) — in that pool
- Store data that is needed for snapshots of storage objects in the pool
- Track changes to replicated storage objects in that pool

Storage pools must maintain free capacity in order to operate properly. By default, Dell EMC Unity will raise an alert if a storage pool has less than 30% free capacity, and will begin to automatically invalidate snapshots and replication sessions if the storage pool has less than 5% free capacity. Dell EMC recommends that a storage pool always have at least 10% free capacity.

### 1.1.2 All-flash pool

All-flash pools provide the highest level of performance in Dell EMC Unity. Use an all-flash pool when the application requires the highest storage performance at the lowest response time.

- Dell EMC FAST™ Cache and FAST VP are not applicable to all-flash pools.
- Compression is only supported on an all-flash pool.
- Snapshots and replication operate most efficiently in all-flash pools.
- Dell EMC recommends using only a single drive size and a single RAID width within an all-flash pool.

For example: For an all-flash pool, use only 1.6TB SAS flash 3 drives and configure them all with RAID 5 12+1.

### 1.1.3 Hybrid pool

Hybrid pools are not applicable when using Dell EMC Unity All-Flash arrays.

## 2 Dell EMC Unity features

This section describes some of the native features available on the Dell EMC Unity platform. Additional information on each of these features can be found in the *Dell EMC Unity: Best Practices Guide*. Features not applicable to the all-flash array models covered by this paper are noted.

### 2.1 FAST VP

FAST VP accelerates performance of a specific storage pool by automatically moving data within that pool to the appropriate drive technology based on data access patterns. FAST VP is only applicable to hybrid pools within a Dell EMC Unity Hybrid flash system.

### 2.2 FAST Cache

FAST Cache is a single global resource that can improve performance of one or more hybrid pools within a Dell EMC Unity Hybrid flash system. FAST Cache can only be created with SAS flash 2 drives, and is only applicable to hybrid pools.

### 2.3 Data reduction

The Dell EMC Unity Data Reduction feature is available for block LUNs and VMFS datastores in an all-flash pool starting with Dell EMC Unity OE version 4.1. Data reduction is available for file systems and NFS datastores in an all-flash pool starting with Dell EMC Unity OE version 4.2.

Data reduction can increase the overall CPU load on the system when storage objects service reads or writes of compressible data, and may increase latency when accessing the data. Before enabling Data Reduction on a storage object, it is recommended to monitor the system and ensure the system has available resources to support it. (Refer to the “Hardware Capability Guidelines” section and Table 2 in the *Dell EMC Unity: Best Practices Guide*.) Enable data reduction on a few storage objects at a time and then monitor the system to be sure it is still within recommended operating ranges, before enabling data reduction on more storage objects. Additional information regarding data reduction can be found in the *Dell EMC Unity: Compression* white paper.

Compression will only provide space savings if the data on the storage object is at least 25% compressible. Before enabling compression on a storage object, determine if it contains data that will compress; do not enable compression on a storage object if there will be no space savings. Contact your Dell EMC representative for tools that can analyze the data compressibility. Additional information regarding compression can be found in the [Dell EMC Unity: Data Reduction](#) white paper.

Linked clones are a very common VDI configuration. This workload has a small footprint with reduced data deduplication by its very nature. Choosing to enable data reduction may not produce much space savings and it's possible that any space savings gained by enabling data reduction may not offset the performance impact.

### 2.4 Data at Rest Encryption

Data at Rest Encryption (D@RE) is controller-based encryption that does not impact system performance; therefore, Dell EMC recommends ordering Dell EMC Unity systems as encryption-enabled, if appropriate for your environment.

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**Note:** Encryption can only be enabled at the time of system installation with the appropriate license.

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If encryption is enabled, Dell EMC recommends making external backups of the encryption keys after system installation as well as immediately following any change in the system's drive configuration (such as creating or expanding a storage pool, adding new drives or replacing a faulted drive). Additional information regarding Data at Rest Encryption can be found in the [Dell EMC Unity: Data at Rest Encryption](#) white paper.

## 2.5 Host I/O limits

Dell EMC recommends setting Host I/O limits on workloads that might monopolize pool resources and starve other applications of their required performance.

For example: Limit the bandwidth available to large-block applications that may be increasing the latency on other small-block workloads.

Additional information can be found in the [Dell EMC Unity: Unisphere Overview](#) white paper.

## 3 VDI design considerations

VDI workloads are some of the most I/O-intensive workloads an array will support. The number of concurrent users and applications used will determine the exact I/O load. The capacity requirements for VDI tend to be small compared to the throughput requirements. This is especially true for linked clone deployments.

### 3.1 Linked clone pools

Linked clones are very common in VDI deployments because of the ease of management, small footprint, and consistency. Since a base image is used for deployment, all desktops will be consistent. When upgrades are required, a new image is deployed, upgrading all machines quickly and easily.

One of the tradeoffs of linked clones is reduced customization without additional tools. In order to retain the ease of management and reduced footprint all machines are mirrored to a base image. While persistent desktops can be enabled, this branches the machine images and makes machine replacement more challenging.

For large numbers of identical desktops, linked clones are the most efficient method, and one of the most common.

### 3.2 Full clones

VMware Horizon® does support managed full clones. They have a much larger footprint and require individual updating, or redeployment on update. They also require far more storage space. This can be offset by leveraging deduplication, but this does have a performance impact and typically cannot match the capacity savings of linked clones.

### 3.3 Persistent and non-persistent desktops

Linked clone desktops can be created in a persistent manner. This allows users to save customizations to their desktops and even keep files on the desktop of their virtual machines. This does allow users a more customized environment but increases the cost of management. Persistent desktops cannot be replaced without a method of retaining users' files and settings.

Non-persistent desktops have a far lower management cost. If a desktop becomes corrupt, there is no intervention required in most cases to repair it. When a user logs out, the desktop is reset to the base image automatically. This ensures users will always have a clean desktop to work with. The tradeoff is increased storage load. Each time a user logs out, the changes are thrown away and a replacement change file needs to be created. This increase in I/O needs to be accounted for.

### 3.4 Storage pools

In general, it is recommended to use fewer storage pools within Dell EMC Unity storage because this reduces complexity and increases flexibility. Dell EMC recommends using a single virtual disk pool for hosting VDI desktop volumes. This provides better performance by leveraging the aggregate I/O bandwidth of all disks to service I/O requests from the VMware ESXi™ hosts. A single drive pool also allows all hosts to share the volumes enabling VMware vSphere® vMotion®. This will enable hosts to be put into maintenance mode and virtual machines to be moved without taking an outage. This greatly simplifies host updates and patches.

If file services will be provided on the same storage, those requirements will determine if more pools are justified. The requirements for file storage are not covered in this document.

### 3.4.1 RAID configurations

By default, Dell EMC Unity chooses RAID 5 as the RAID protection level when creating a new storage pool. The I/O requirements for the VDI desktops need to be clearly defined in order to size the storage correctly. The RAID type chosen will be determined by comparing availability performance requirements. The small footprint and high I/O density will typically allow a smaller drive size, reducing drive rebuild times. This means RAID 5 would be preferred over RAID 6 in most cases.

## 3.5 Validating the storage design

VDI workloads can be challenging to simulate. The fact they consist of hundreds to thousands of virtual machines makes it difficult to recreate the load. There are few tools that can accurately simulate this.

The tool used for this design was Login VSI. It allows controlling a large number of virtual machines in a consistent manner.

In order to accurately create the storage load, the following needs to be completed:

- Create the base image to match the intended configuration
- Simulate the correct user count
- Run the applications as a user would
- Determine the optimum number of volumes based on recover requirements and management overhead
- Baseline the number of I/Os and GBs per user to determine the storage requirements

### 3.5.1 Validating the I/O path

VDI workloads tend to be fairly small block. The average I/O size will typically be between 24k and 32k. The number of I/Os generated will be fairly high because of the number of users per volume.

Spreading users across more volumes will typically return better performance, within reason. 20–30 volumes will support 3,000 users. For a smaller number of users, fewer volumes can be used. More volumes require additional management effort but will spread I/O across more LUNs for better performance. It will also mean smaller volumes for recovery or replication purposes.

Because of the small I/O size of VDI workloads, bandwidth is typically not a limiting factor. With modern 16Gb or higher Fibre Channel or 10Gb or higher Ethernet architectures, the number of ports has become less of an issue. Four ports per service processor will easily handle 3,000 VDI users.

### 3.5.2 Validating the drives

Once the I/O path has been validated, the next step is to test the drives. For best results when testing drives on a Dell EMC Unity array, use the following guidelines when configuring the test.

- In a dual-controller system, use at least one volume per controller. This ensures that I/O will be distributed across both controllers. Using both controllers more closely simulates real-world activity. For best results, use the same number of volumes on each controller. For VDI, having more LUNs is better, and up to 30 volumes may be required to achieve maximum performance.
- When performing I/O tests on any storage platform, it is important to use datasets that are larger than the controller cache. For more accurate results, create enough VMs to push the controllers to the target limits.
- The Login VSI tool runs actual virtual machines and user applications and is the best way to simulate users. Because of the complexity of running thousands of VMs and the possible production impact, it may not be practical. To simulate the workload using other tools such as Iometer, a workload pattern and queue depth must be created. The I/O size for VDI will be 24–32k, 80% writes, 100% random, and a large number of I/O streams. The last part is the most challenging. The true impact of VDI is the number of volumes/streams writing data simultaneously.

The purpose of this type of testing is to validate that the storage design will provide the required throughput and IOPS with acceptable latency. It is important that the test does not exceed the designed capacity of the array. For example, an array designed for a workload of 5,000 IOPS is likely to perform poorly with a workload of 10,000 IOPS. If a test is generating a workload higher than the designed capacity, adjust the workload being generated by reducing the number of threads and/or outstanding I/Os.

The results of the Live Optics analysis provide an I/O target to simulate using these tests. To truly test the array, the designed workload should be simulated at a minimum, and slightly higher if possible. To ensure the array has headroom for load spikes, the throughput should be tested slightly beyond estimated production loads.

Composing and reconfiguring workstation pools will generate additional load beyond user steady state. For 3,000 users, the steady state load was just under 24,000 IOPS. If new images are being tested and deployed at the same time users are working, that additional overhead must be accounted for and provided for. If the additional performance is not available, users will notice a performance impact while the maintenance is occurring.

## 4 VDI test configuration

This section describes the VDI configuration used. There are many options for running VDI workloads on Dell EMC Unity hardware. The choice of a linked-clone configuration was chosen because of the high adoption rate among Dell EMC customers.

### 4.1 Block storage configuration

The storage configuration chosen was block storage. NFS can be used for VM storage since ESXi supports NFS-based datastores but there was no benefit to using file-based storage for these tests.

#### 4.1.1 Pools

The pool was created as a dynamic pool using RAID 5. This gave the best balance of performance, capacity, and rebuild times. RAID 1/0 can be used if additional performance is desired over capacity. RAID 6 would not typically be used because of the smaller drive sizes and performance requirements of VDI.

#### 4.1.2 Volumes

The volume size used was 2 TB. This is to allow the VMs to grow as needed and VMware Horizon to detect the volume space for VM growth. Horizon will monitor drive capacity available and prevent VM placement on a volume that it deems too full. This is a safety feature to prevent over-allocation to the point of failure. There are settings to allow more aggressive VM placement, but they require administrators to closely monitor volume utilization to ensure volumes do not fill up or require an automated process to grow volumes before they reach capacity.

Dell EMC Unity storage can dynamically expand volumes quickly and easily if needed. This ability can prevent Horizon from halting VM creation if a volume is approaching capacity.

### 4.2 File storage considerations

Creating SMB or NFS file shares for user data storage allows a single appliance to serve all storage needs for all data types. This reduces the number of devices required to service user needs. It also simplifies licensing and support.

Since Horizon supports a combined file solution with Microsoft® Windows® and Linux® VMs, it allows all desktop types to share a storage platform.

#### 4.2.1 NAS server

Dell EMC Unity storage provides an integrated NAS solution that supports user profile redirection, file shares, application install shares, and home directories. This provides a single appliance for administration for complete VDI solutions.

With built-in replication, multi-site configurations can also be simplified. This document does not cover all optional solutions.

#### 4.2.2 VMware datastore

For NFS-based datastore environments, the performance needs to be verified. The goal of this document is not to explore the performance of all available options, but provides a template for a block-based solution.

## 4.3 VM performance

### 4.3.1 Memory

Virtual machine performance will be greatly affected by the quantity of memory allocated to each VM. This is the most effective way to improve performance in virtual machines, but it can be difficult to scale to large environments because of the aggregated quantity. For the purposes of this document, 3 GB per VM was allocated.

Decreasing the amount of memory allocated will result in more storage load. The impact on storage should be tested. Baselining a single VM will give a good indication of storage load per VM. This will give a starting point for I/O load but many other factors will affect the total performance.

### 4.3.2 Host-based caching

The host configuration can change the load generated to the storage. One of the configuration options is content-based read cache which is enabled through Horizon View Storage Acceleration. This option will use host RAM to accelerate reads during boot events. This can reduce volume reads and improve boot times for virtual machines.

The tradeoff is increased host memory load. On hosts that are memory constrained, this may not be an option. For environments that can spare memory, this can improve the boot times of the virtual machines when large numbers of machines are requesting the same data.

### 4.3.3 VMware OS optimization

VMware offers a free tool to optimize virtual machines. It is a profile-based optimization tool that can greatly reduce the resource requirements for virtual machines.

Login VSI has created a profile for VM optimization that reduces memory, disk, and CPU requirements to allow a greater number of virtual machines per host. It can have a negative impact on some applications so testing is required. The overall impact considerably reduces host requirements for virtual machines allowing a much greater number per host.

The Windows 10 Login VSI profile was used to optimize the tested machines. More information can be found in the article [Optimizing desktop images with VMware OSOT](#). Login VSI provides guidance on how the profile will change the behavior of virtual machines when applied.

Testing should be done once an optimization profile has been applied to ensure users are still able to use the desktops. The modifications favor performance and may require tuning to allow all applications to function correctly.

## 5 Dell EMC Unity features

There are several features included in Dell EMC Unity that when used may provide additional value. Some may have performance impacts.

### 5.1 Data reduction

The Dell EMC Unity Data Reduction feature includes both zero detection and compression, providing next-level space conservation. By offering multiple levels of space savings, Dell EMC Unity storage provides flexibility for the best balance of space savings and performance.

Dell EMC Unity offers in-line data reduction for all-flash storage pools. The actual data reduction ratio depends on the type of data being stored. Because of the highly variable nature of the data being used in virtual machines, actual user data needs to be tested. Many applications now include native compression and may not allow additional space savings.

Data reduction requires CPU resources, and at high throughput levels, can start to have an impact on performance. The heavy write ratio of VDI workloads can also reduce the benefits of data reduction for OS datastores. File data can compress well, so selective-volume data reduction should be considered.

File shares and user home directories are excellent candidates for data reduction. User profiles can also be a target, but care must be taken and profile performance must be evaluated. User profile access times can have a large impact on login times and should be tested carefully.

### 5.2 Advanced deduplication

In addition to data reduction, the Dell EMC Unity Advanced Deduplication feature can be enabled if data reduction is enabled. It provides the ability to reduce the amount of storage needed for user data by keeping only a small number of copies (often just one copy) of a data block with a given content. The deduplication scope is a single LUN, so keep this in mind when choosing the storage layout. Fewer LUNs will result in better deduplication, but more LUNs are needed for maximum performance.

This level of space savings can provide the greatest level of return in most environments. Because of the nature of user data, there will be duplicate data from copies of documents to duplicate Windows files. However, this process also requires the most CPU resources. This feature should be tested at the projected user workload before being enabled in production.

The average space savings during these tests was 3.2 to 1 across all the volumes in the pool.

### 5.3 Snapshots

Dell EMC Unity snapshots can be used to protect and recover data quickly and easily. They allow reverting volumes in seconds to recover files or even entire machines.

In VDI environments, snapshots provide a rapid way to recover user data. If a used file is deleted and the volume has been snapped, it can be used to rapidly recover one or many files quickly.

OS image volumes are typically static and benefit less from snapshots. However, the base image should have a snapshot taken in case a change is made that needs to be reverted quickly.

## 5.4 Replication

Dell EMC Unity storage has a robust replication mechanism that supports both volume- and file-level replication for multi-site access or disaster protection. This allows users in multiple sites to have access to the same file system.

Volume-based replication can keep base image volumes in sync at multiple sites. This promotes consistency across a large organization by ensuring the same base images are used in all site.

More information about Dell EMC Unity replication can be found in the [Configuring Replication](#) document.

## 5.5 Data at Rest Encryption

The use of encryption can be used to create highly secure data storage for sites that require it. For the purposes of this test it was not enabled.

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**Note:** Data at Rest Encryption (D@RE) is a license-able feature and must be selected during the ordering processes and licensed at system initialization. D@RE cannot be enabled at a later time.

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## 5.6 Host I/O limits (QoS)

Typically, a Dell EMC Unity array is used to service multiple hosts and applications. These applications can have different service levels and different storage demands. In addition, a single array can be providing services to multiple environments such as development and testing as well as production. Traditionally, these scenarios have been difficult to manage to ensure that critical applications get the resources they need while managing less-critical applications to make sure they do not over-consume resources.

Host I/O limits or Quality of Service (QoS) provide an excellent means to manage these types of workloads. Instead of trying to manage these workloads with multiple storage pools, host I/O limits allow LUNs to be restricted to a specified amount of IOPS or bandwidth so they do not adversely impact other applications. Also, this allows storage administrators to ensure applications and environments adhere to budgeted limits which greatly simplifies planning and management.

Care must be taken enabling this in VDI environments if the vMotion feature is enabled. Machines can be automatically relocated if a host becomes overloaded and there are resources available on another host. This is the recommended configuration. Hosts must be sized to run enough concurrent desktops to support user demand. Throttling may impact SLAs.



## 6 Testing results

There are two phases that VDI spends significant time and resources supporting: login and steady state. They are the primary concerns for administrators since they happen every single work day. These two phases must perform well for an environment to be user friendly.

The boot phase is far less common and only happens in specific circumstances. This phase is far less important because it normally happens outside business hours and has very little user impact.

The environment used for the testing is documented in appendix A.

### 6.1 VDI performance data

The profile used was the default Knowledge Worker profile. It covers the majority of the core applications deployed and generates a balanced workload. Here is the detail of the workload from the [Login VSI Workloads](#) page:

The Knowledge Worker is designed for 2(v)CPU environments. This is a well-balanced intensive workload that stresses the system smoothly, resulting in higher CPU, RAM and IO usage.

The Knowledge Worker workload uses the following applications:

- Adobe Reader
- Freemind/Java
- Internet Explorer
- MS Excel
- MS Outlook
- MS PowerPoint
- MS Word
- Photo Viewer

It also uses native Windows apps (Notepad and 7-Zip) to complete the print and zip actions used by the workload meta functions.

By using a standardized profile the workload generated can easily be duplicated or verified in any environment.

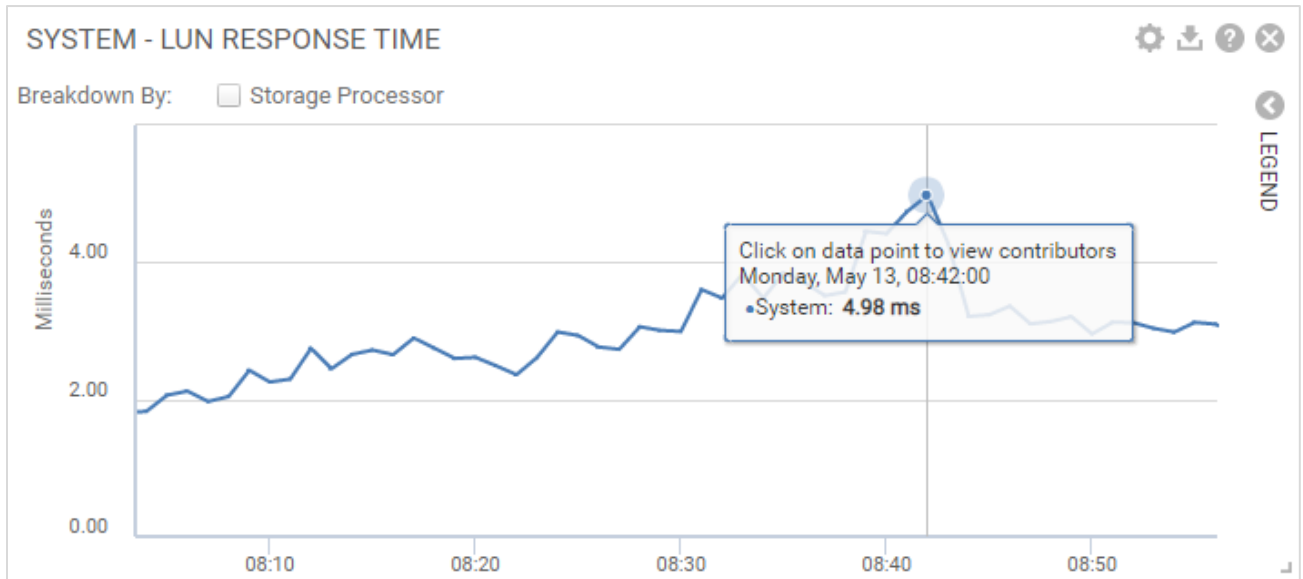
#### 6.1.1 Login

The login cycle was set to one login per second until all VMs are logged in. Once VMs are logged in, they start the workload and the login load overlays the steady-state workload until all users are running the workload.

The following sections detail the various phases of the test run.

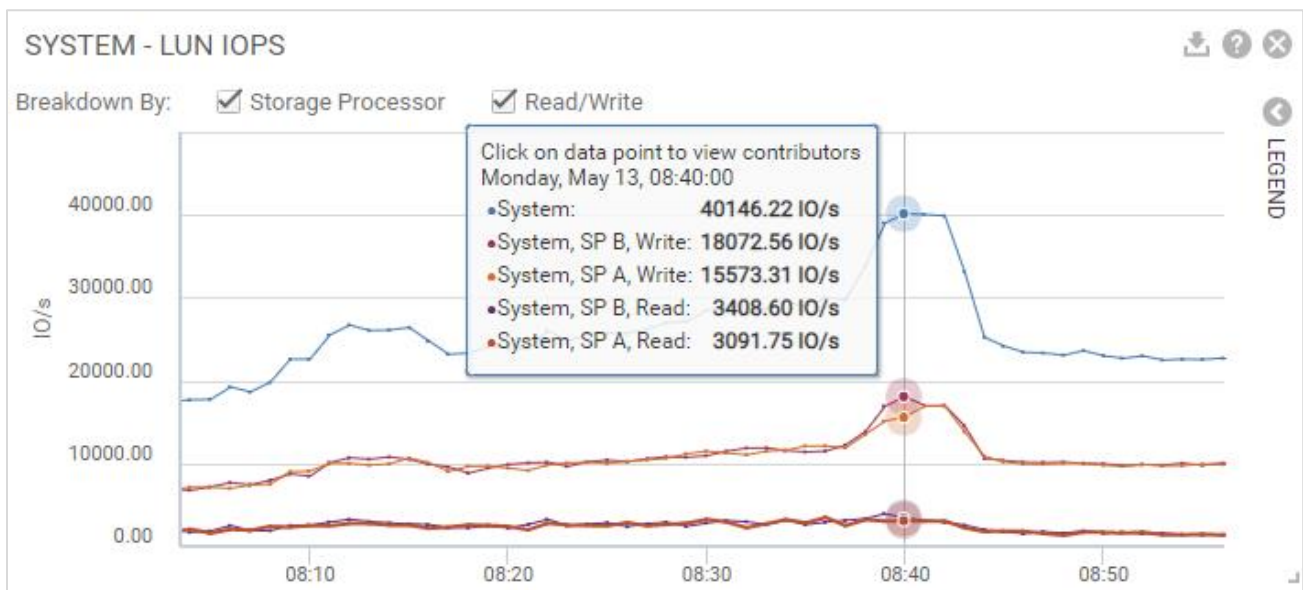
### 6.1.1.1 Latency

The following latency chart shows the latency change over time as the workload increases. The peak latency achieved was less than 5 ms. The response was excellent throughout the test run.



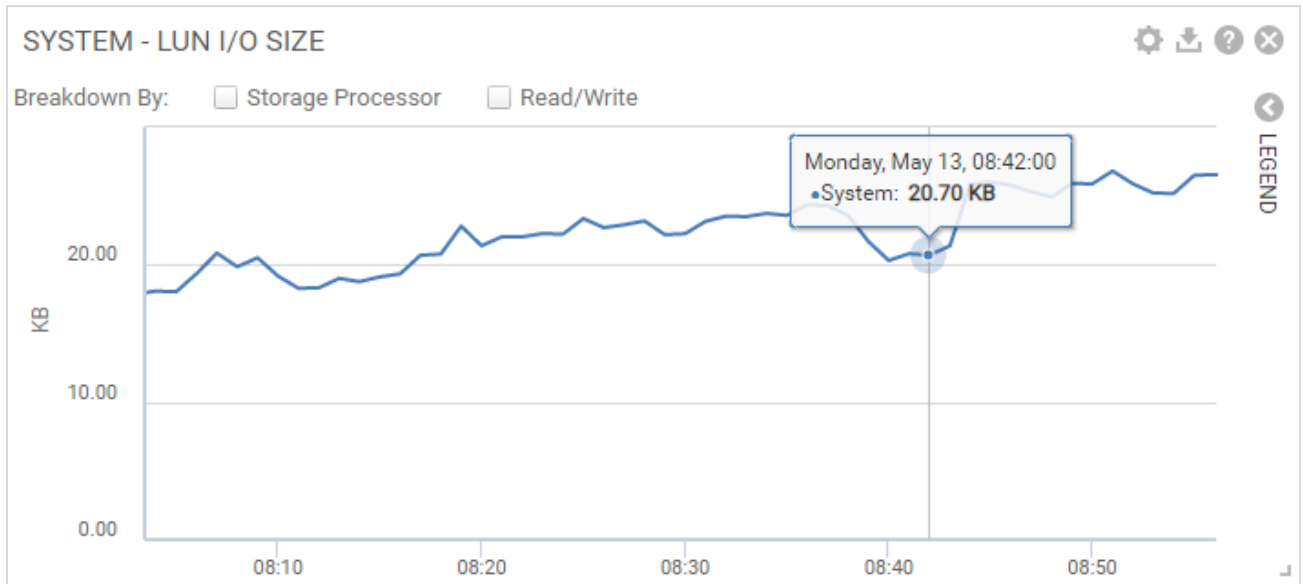
### 6.1.1.2 IOPS

The during the test run, IOPS peaked at just over 40,000. The equates to about 13.4 IOPS/user. This will change depending on the workload. The application in each environment will determine the actual workload generated.



### 6.1.1.3 I/O size

The I/O size varied during the test run from 20–25k. The number and size of IOPS will show bandwidth required to support the workload.

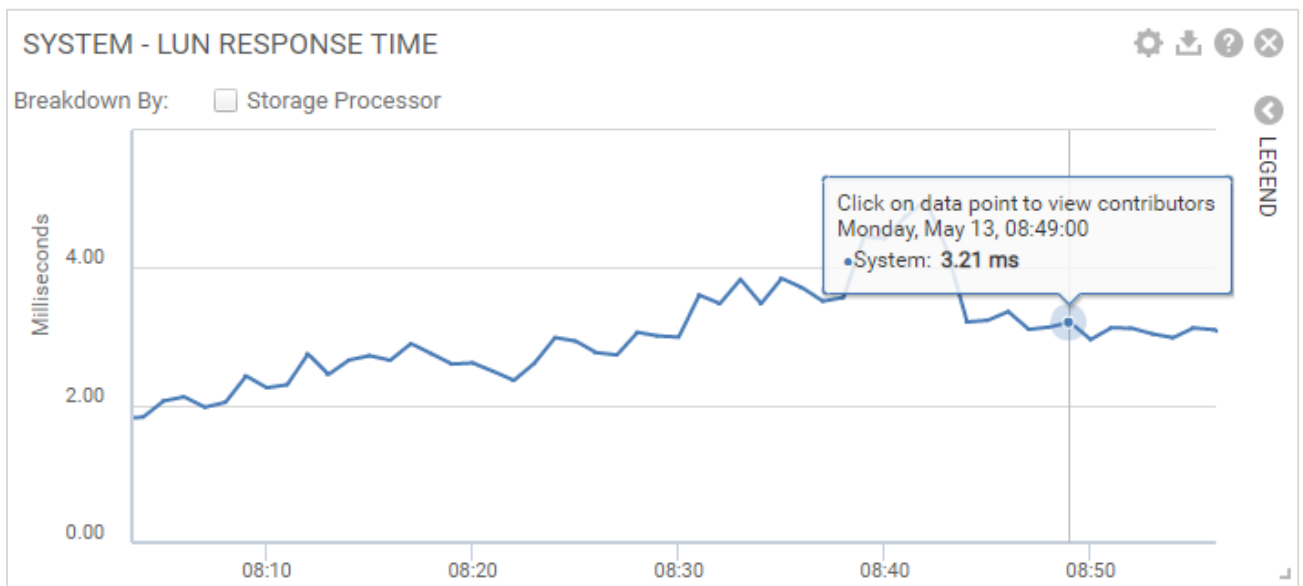


### 6.1.2 Steady state

The steady state is the most prevalent condition for a VDI environment. This is the most important state since it impacts user productivity. A storage array should be tested thoroughly in this state to ensure user experience is excellent.

#### 6.1.2.1 Latency

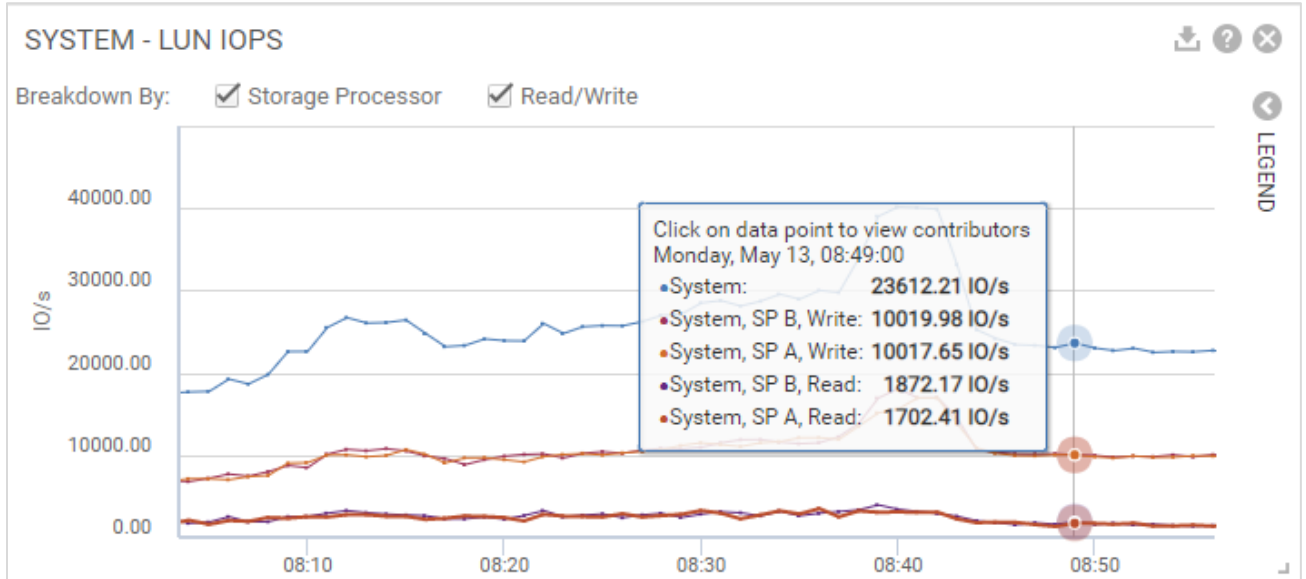
The steady-state I/O latency during the workload run was less than 3.5 ms with advanced deduplication enabled. The average data reduction ratio was 3.2 to 1. Even with advanced deduplication enabled, the latency was less than 4 ms.



### 6.1.2.2 IOPS

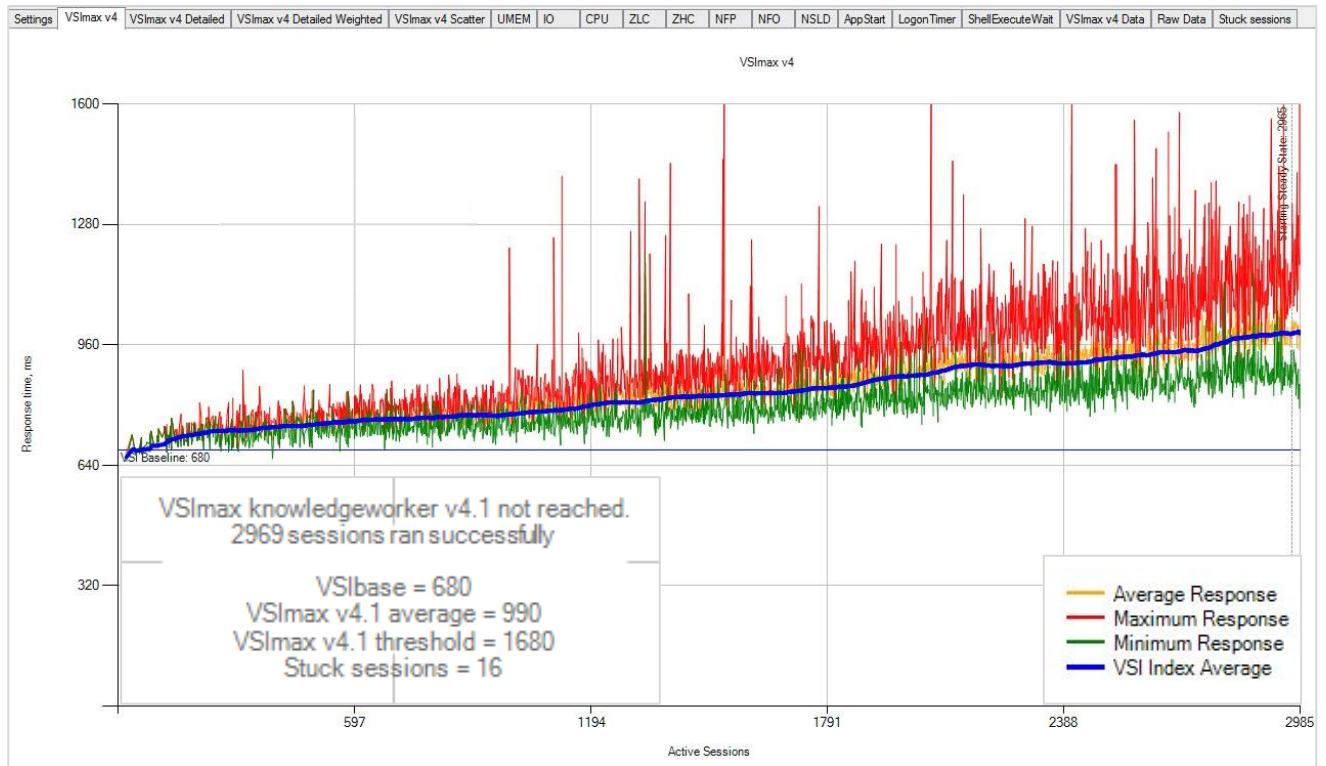
Actual workloads will vary based on the applications being used, the amount of data being accessed, and the user work patterns. The load shown above is based on a simulated knowledge worker. The profile is a pre-defined workload created by Login VSI as a standardized workload.

The read/write ratio is over 80% writes, which is common for VDI workloads.



## 7 Login VSI results

The results show that the threshold for latency was not reached and all sessions completed successfully. The available performance headroom ensures the storage is capable of handling spikes in I/O without impacting performance.



The Login VSI test results show the Dell EMC Unity 680F to be a very capable platform for supporting 3,000 concurrent users with data reduction and advanced deduplication enabled. The results show the system had performance to spare. Additional features such as integrated CIFS or NFS file could be enabled without adding hardware.

The Dell EMC Unity platform has a number of models to serve customer large or small, and the ability to provide excellent block storage and integrated file in a cost- and space-efficient architecture.

## A Environment

### A.1 Horizon View

Table 1 Horizon View configuration

Component	Description
Horizon View	7.8
Role	Virtual machine assignment, management, web interface, connection broker, Composer
Servers	Four 4-core servers, 16 GB RAM each, 2 Composers, 2 Connection servers
Cabling	10Gbps VMXNet3

### A.2 VMware hosts

Table 2 VMware host hardware configuration

Component	Description
VMware host	6.7u2
Role	End-user compute node
Hardware	Two 18-core processors, 576 GB RAM
Storage	200 GB SSD for boot/log

### A.3 VMware vCenter

Table 3 vCenter server configuration

Component	Description
VMware vCenter appliance	6.7, two virtual vCenter appliances for end-user VMs, one appliance for infrastructure
Role	Management of all hosts, DRM load balancing, host monitoring

## A.4 Login VSI

Table 4 Login VSI configuration

Component	Description
Login VSI	4.1.32
Role	Workload generation and application performance reporting

## A.5 Windows desktops

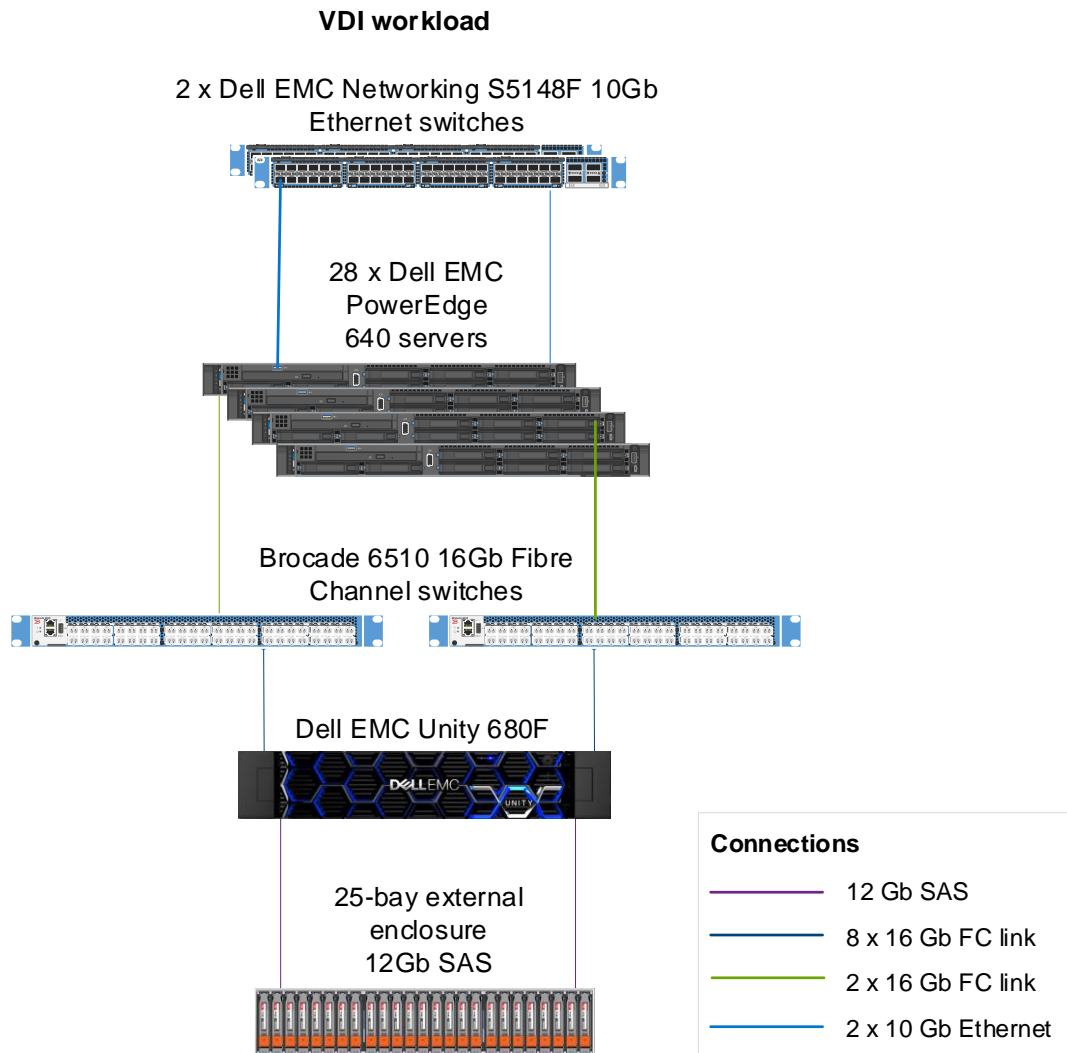
Table 5 Virtual desktop configuration

Component	Description
Client desktops	Windows 10
Memory	3 GB
Processor	2 vCPUs
Applications	Office 2016, Adobe® Reader, WinZip®, Freemind, Doro PDF Writer

## A.6 Hardware components

Component	Description
Fibre Channel switches	Two Brocade® 6510 switches for dual fabric
Network switch	Two Dell EMC Networking S5148F switches
Servers	Dell PowerEdge™ 640, two Intel® Xeon® Gold 6154 CPU @ 3.00 GHz, 576 GB RAM
Network adapters	Dual built-in 10Gb Ethernet adapters
Fibre Channel adapters	QLogic® 2692 dual-port 16Gb

## A.7 Logical diagram



## A.8 Storage array

The Dell EMC Unity 680 array was tested with 36 SSDs and with data reduction and advanced deduplication enabled. Additional configuration details include the following:

- Dell EMC Unity 680F All Flash array
- 36 3.84 TB SSDs
- Dell EMC Unity 12Gb SAS external enclosure
- 4 x 12Gb SAS ports per storage processor
- 8 x 16Gb Fibre Channel ports per storage processor
- Dual storage processors
- Dual power supplies

Visit the [Dell EMC Unity Family page](#) for more product information and specifications.



## B Technical support and resources

[Dell.com/support](https://dell.com/support) is focused on meeting customer needs with proven services and support.

[Storage technical documents and videos](#) provide expertise that helps to ensure customer success on Dell EMC storage platforms.

[Dell EMC Unity Info Hub](#) is a source providing helpful links to document and tools to customers.

### B.1 Dell EMC resources

See the following additional publications on [Dell EMC Unity technical documents and videos](#):

- Dell EMC Unity: Best Practices Guide
- Dell EMC Unity: NAS Capabilities
- Dell EMC Unity: Dynamic Pools
- Dell EMC Unity: Data Reduction
- Dell EMC Unity: Performance Metrics
- Dell EMC Unity: Replication Technologies
- Dell EMC Unity: Snapshots and Thin Clones
- Dell EMC Unity: Unisphere Overview

### B.2 VDI resources

There is a tremendous amount of SQL Server information available online. While not complete, the list below contains several useful links.

Table 6 Useful links

Description	Link
Dell VDI storage solutions	<a href="https://www.dell.com/en-us/glossary/vdi-storage.htm">https://www.dell.com/en-us/glossary/vdi-storage.htm</a>
VMware Horizon home page	<a href="https://www.vmware.com/products/horizon.html">https://www.vmware.com/products/horizon.html</a>
Dell Technologies VDI	<a href="https://corporate.delltechnologies.com/en-us/newsroom/dell-technologies-updates-vdi-complete-solutions-and-unveils-its-most-versatile-thin-client-ever.htm">https://corporate.delltechnologies.com/en-us/newsroom/dell-technologies-updates-vdi-complete-solutions-and-unveils-its-most-versatile-thin-client-ever.htm</a>