VMware Mirage Large-Scale Reference Architecture
VMware Mirage 5.0 and Later
Supporting the Backup and Migration of Large Deployments
TECHNICAL WHITE PAPER
# Table of Contents

Executive Summary ......................................................... 4  
Mirage Solution Overview .................................................. 5  
  Solution Software Components ......................................... 5  
    VMware vSphere ........................................................... 5  
    VMware Mirage .......................................................... 5  
  VMware Mirage Components ............................................. 5  
    Mirage Management Server ............................................ 5  
    Mirage Server ............................................................ 5  
    Mirage Web and Protection Manager ................................... 6  
    Mirage Client ............................................................. 6  
    Mirage Branch Reflectors .............................................. 6  
    Mirage File Portal ...................................................... 6  
Performance Measurements .................................................. 7  
  Cacti Graphing Solution ................................................ 7  
  RRDtool v. 1.3 ............................................................. 7  
  SNMP Informant ............................................................ 7  
  EMCO WakeOnLan .......................................................... 7  
  SolarWinds IP Address Manager ......................................... 7  
Hardware Components .......................................................... 7  
  Server .............................................................................. 7  
  Network ........................................................................... 8  
  Storage ............................................................................. 8  
  Desktops ........................................................................... 8  
Use Case Overview .............................................................. 9  
Reference Architecture Overview ........................................... 10  
  Network Considerations and Configuration ......................... 11  
  Storage Considerations and Configuration .......................... 13  
  External Infrastructure Components .................................... 15  
  Endpoint Centralization .................................................... 15  
Test Results: Centralization over Typical LAN .............................. 16  
  Total Centralization Time ................................................ 16  
  Endpoint Centralization: Resource Consumption ................... 19  
Test Results: Windows 7 Migration of 825 Endpoints over LAN ........ 21
Executive Summary

This VMware® Mirage™ large-scale reference architecture solves two common challenges faced by IT managers today:

1. How to back up a large number of desktops deployed throughout the enterprise while protecting the customization, applications, and data that personalize each system for its end user.

2. How to migrate thousands of desktops from Microsoft Windows XP to Windows 7 efficiently, with minimal impact on IT resources and end-user productivity.

Both tasks typically require a substantial investment in IT resources and the use of separate backup and PC lifecycle management tools. VMware Mirage, however, performs both tasks efficiently. The test results in this paper show that Mirage delivered even better results than initially expected. VMware Mirage

• Efficiently backed up desktops located on a local area network (LAN), slashing the amount of data transferred to the data center by up to 32 percent through its deduplication and compression capabilities.

• Increased system performance to match increased network bandwidth, linearly decreasing the amount of time required to back up desktops.

• Migrated up to 800 desktops concurrently from Windows XP to Windows 7 in a short time, requiring minimal IT resources and bandwidth.

• Reduced end-user downtime and resulting productivity loss during the migration to 26 minutes on average.

This reference architecture and the real-world testing behind it are provided to help guide the planning and design of other successful Mirage implementations.
Mirage Solution Overview

VMware Mirage provides centralized image management for Windows desktops, with enhanced backup and OS migration capabilities. Designed to simplify and reduce the cost of critical help desk tasks while minimizing interruption to end users, VMware Mirage provides the following key capabilities:

- **Seamless desktop backup, recovery, and repair** – You can store full desktop snapshots in the data center with synchronization of IT- or end-user-initiated changes. Centrally stored desktop images and periodic endpoint snapshots allow IT to roll back (recover) partial or full desktops when needed. You can troubleshoot and fix endpoints quickly with the Mirage Web Manager.

- **Simplified Windows 7 migrations** – Mirage accelerates the most common approaches to Windows 7 migrations: upgrading an existing Windows XP device to Windows 7 or migrating an end user’s profile and files to a new Windows 7 machine.

- **Layered endpoint management and application layering** – Mirage enables you to manage PCs, or VMware Horizon™ with View™ persistent virtual desktops, as a set of logical layers owned by either IT or the end user. Update IT-managed layers while maintaining end-user files and personalization. It is easy to deploy applications or VMware ThinApp® packages to any collection of end users with Mirage application layering technology.

- **Branch office optimization** – The Mirage branch reflector allows IT to download any images and updates once from the Mirage server across the WAN, using peer-to-peer technology to distribute them to other Mirage clients in the branch office.

- **Bring Your Own Device (BYOD)** – You can install virtual images, which Mirage manages natively, onto Windows PCs running VMware Workstation™, or onto VMware Fusion® Pro virtual desktops. The Fusion desktops can run on Windows, Macintosh, or Linux computers. Mirage allows end users to leverage local system resources for online and offline productivity.

Solution Software Components

This solution uses two major VMware software components:

- **VMware vSphere**
  The industry-leading virtualization platform for building cloud infrastructures, VMware vSphere® enables users to run business-critical applications with confidence and respond quickly to business needs. vSphere accelerates the shift to cloud computing for existing data centers and underpins compatible public cloud offerings, forming the foundation for the industry’s best hybrid cloud model.

- **VMware Mirage**
  Mirage software centralizes desktops in the data center for management and protection purposes, distributes desktop workloads to the endpoints, where they can run with native efficiency, and optimizes the transfer of data between endpoints and the data center.

VMware Mirage Components

Mirage consists of the following software components:

- **Mirage Management Server**
  The Mirage Management server controls and manages the Mirage server cluster and coordinates all Mirage operations, including backup, migration, and operating system deployment.

- **Mirage Server**
  Mirage servers perform backups, migrations, and the deployment of base and app layers to endpoints. Multiple Mirage servers can be deployed as a server cluster to provide system redundancy and support larger organizations.
Mirage Web and Protection Manager
These Web-based tools enable help desk personnel to respond efficiently to service queries and ensure that endpoints are protected by Mirage backup capabilities.

Mirage Client
The Mirage client enables an endpoint to be managed by Mirage. It supports both physical and virtual desktops including those hosted by both Type 1 and Type 2 hypervisors.

Mirage Branch Reflectors
The role of a branch reflector is to offload the deployment of base layers and migration of endpoints from the Mirage server cluster, reducing both time and network bandwidth required. Because this paper focuses on a LAN deployment, branch reflectors were not required. It is possible to use branch reflectors in LAN scenarios, but covering this use case fell outside the scope of this paper. Any Mirage endpoint can be configured as a branch reflector and can be dedicated or shared with low-resource uses such as information kiosks.

Mirage File Portal
The Web-based Mirage file portal provides browser-based access to user files backed up by Mirage. Using any device that has a Web browser, including smartphones and tablets, end users can access and restore their critical data without having to be at their desks or usual computers.

For links to more detailed information about Mirage capabilities, features, and system components, see the References at the end of this document.

Figure 1: Mirage Components
Performance Measurements

We used multiple tools to monitor the performance of all the hardware and software components during the testing period. Testing components included

Cacti Graphing Solution
Cacti is a complete network graphing solution designed to harness the power of RRDtool data storage and graphing functionality. Cacti provides a fast polling interval, advanced graph templates, multiple data acquisition methods, and user management features out of the box.

RRDtool v. 1.3
RRDtool is the Open Source industry-standard, high-performance data logging and graphing system for time series data.

SNMP Informant
SNMP Informant uses the Simple Network Management Protocol (SNMP) to collect performance, state, operational, and custom information.

EMCO WakeOnLan
All physical endpoints were powered on and off remotely. This utility allows powering up of multiple network PCs and includes a MAC address detection feature that fulfilled a key requirement for this paper, enabling the discovery of new physical endpoints as the project progressed.

SolarWinds IP Address Manager
We used this IP scanner to track changes between WakeOnLan database information and the physical machines on the network that were currently powered on. The use of this optional tool simplified keeping track of IP-to-endpoint FQDN information.

Hardware Components

This reference architecture used the following hardware components:

Server
The architecture includes three HP ProLiant BL460c server blades that plug vertically into the BladeSystem c7000 enclosure. Components of the HP ProLiant system include

• BL460c Gen8 Intel Xeon E5-2670 (2.60GHz/8-core/20MB/115W) Processor Kit
• BLC VC 8GB FC 24-Port Option Kit
• 2400W High-Efficiency Power Supply
• ProLiant BL460c Gen8 10Gb
• 300GB 2.5" Internal Hard Drive – SAS – 10000RPM – Hot Pluggable
• Memory – 16GB – DIMM 240-pin – DDR3 – 1600MHz / PC3-12800 – CL11 - registered – ECC
• Flex-10 10Gb 2-port S30FLB Adapter – network adapter – 2 ports
• BladeSystem c-Class 10Gb Short Range Small Form-Factor Pluggable Option
• Virtual Connect Flex-10/10D module for c-Class BladeSystem
Network
The HP 5400 zl Switch consists of advanced intelligent switches in the HP modular chassis product line, which includes 6-slot and 12-slot chassis and associated zl modules and bundles. The foundation for the switch series is a purpose-built, programmable ProVision ASIC with 10/100, Gigabit Ethernet, and 10 Gigabit Ethernet interfaces, and integrated Layer 3 features. Components of the HP 5400 zl Switch include:

- HP 5412-92G-PoE+-2XG v2 zl Switch with Premium Software
  - 1500W PoE+ zl Power Supply
  - 24-port Gig-T PoE+ v2 zl Module
  - 20-port Gig-T PoE+ / 2-port 10GbE SFP+ v2 zl Module
- 1500W PoE+ zl Power Supply
- HP X132 10G SFP+ LC SR Transceiver
- HP 24-port Gig-T PoE+ v2 zl Module

Storage
HP StoreEasy 3830 Gateway Storage Blade is a converged storage platform from HP that supports both file and application workloads over ubiquitous Ethernet. The HP StoreEasy3830 is built on industry-standard HP ProLiant BL460c Generation 8 hardware. Components of the HP StoreEasy3830 system include:

- BL460c Gen8 E5-2609 Kit
- 6Gb SAS BL Switch Dual Pack
- D6000 Disk Enclosure
- 300GB 6G SAS 15K 3.5 inch Dp ENT HDD
- D6000 Dual I/O Module Option Kit
- Smart Array P721m/2G FBWC Ctrlr
- Ext Mini SAS 2m Cable Desktop
- 70 hard drives
- Maximum IOPS for the StoreEasy based on the number of drives

Desktops
HP RP5700 Small Form Factor Desktops feature:

- Intel Pentium Dual Core E2160, 1.80GHz, 1MB L2 cache
- 800MHz front side bus
- 80GB internal 3.5 inch 7,200RPM ATA Hard Drive
- 4GB of DDR2-Synch DRAM PC-5300
- Windows XP SP3 and Office 2007 SP3
- Miscellaneous applications (Adobe Reader and Flash, Java)
- An average of 10GB of unique user data
Use Case Overview

The Mirage large-scale reference architecture detailed in this document was designed to solve the two common customer challenges cited in the Executive Summary:

1. How to back up a large number of desktops deployed throughout the enterprise, protecting the unique customization, applications, and data that personalize each system for its end user.

2. How to migrate thousands of desktops from Microsoft Windows XP to Windows 7 efficiently, with minimal impact on IT resources and end-user productivity.

To address these challenges, the customer first conducted a comprehensive assessment of existing desktops and remote office infrastructures. The findings of this assessment were incorporated into the plan and design project that resulted in this Mirage reference architecture.

The test results describe how the customer used Mirage to back up and migrate 800 endpoints from Windows XP to Windows 7. These endpoints, located in a corporate office supported by a Gigabit LAN circuit, typified most of the desktops the customer intends to support with Mirage.

Figure 2: Mirage Endpoint Migration and Backup
Reference Architecture Overview

This customer has offices distributed throughout the world, but this reference architecture focuses mainly on the endpoints that are located at corporate headquarters. All endpoints mentioned in this paper are located near the data center, and can be backed up and migrated over the Gigabit Ethernet network.

The need to back up and migrate these endpoints was urgent because the desktops contained critical data that was not yet saved in the data center. Dispatching technicians to each endpoint to migrate them individually would be costly and inefficient. The customer wanted to avoid manual intervention, to minimize opportunities for human error and free their technicians to perform other tasks, as well as to contain costs.

The customer selected VMware Mirage based on a comprehensive assessment. To successfully design a Mirage infrastructure, it is critical to understand endpoint configuration, health, and utilization, so a proper endpoint assessment should include, at a minimum:

- Machine make and model
- Operating system version, including whether it is 32- or 64-bit
- Total disk space and free disk space
- Amount of unique data that needs to be centralized
- Presence of large files
- Applications installed
- Required hardware drivers
- Peripheral device support

During the migration, the customer’s endpoints contained an average of 34 percent unique data, which needed to be backed up with Mirage before migration to make sure that users’ XP installations could be restored if needed for any reason. By centralizing user data in the data center, the Mirage backup also protected user data on remote desktops from intrusion or other security threats.

The first five endpoints identified for centralization and migration were not in use at the time. They remained online 24 hours per day, so that Mirage was not interrupted by network downtime or by having to throttle, or slow down, its operations to avoid affecting end-user productivity. The desktops were automatically defragmented to eliminate disk fragmentation as an issue.

This created a good reference point on the back-end storage, the Mirage Single-Instance-Storage (SIS). It also provided a good opportunity to demonstrate Mirage deduplication technology, which compares and stores duplicate information only once. Although Windows OS and applications are seldom exactly the same, centralizing five endpoints gave Mirage a good sampling of the information stored on those machines and a fair representation of the common OS files and folders throughout the organization. We refer to this initial phase as warming-up the Mirage SIS.

The endpoints covered here were all located in a corporate office with a Gigabit Ethernet connection to the Mirage server.
The configuration of critical Mirage infrastructure components, all of which are virtual machines, is summarized in Table 1.

<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>DESCRIPTION</th>
<th>VCPU</th>
<th>RAM</th>
<th>HDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mirage server (Mirage version 5.0)</td>
<td>8</td>
<td>16</td>
<td>40GB OS 103GB on SSD (Mirage local cache)</td>
</tr>
<tr>
<td>1</td>
<td>Mirage Management server (Mirage version 5.0)</td>
<td>4</td>
<td>16</td>
<td>40GB OS</td>
</tr>
<tr>
<td>1</td>
<td>HP StoreEasy 3830 (Mirage Storage)</td>
<td>2</td>
<td>8</td>
<td>40GB OS</td>
</tr>
<tr>
<td>1</td>
<td>Microsoft SQL Database Server SQL Enterprise 2008 R2 SP2</td>
<td>2</td>
<td>8</td>
<td>40GB OS 100GB database</td>
</tr>
<tr>
<td>1</td>
<td>Active Directory server Windows 2008 R2 SP2</td>
<td>2</td>
<td>8</td>
<td>40GB OS</td>
</tr>
</tbody>
</table>

Table 1: Mirage Server Configuration

Network Considerations and Configuration

Mirage leverages network connectivity between and among the following:

- **Mirage server and NAS storage** – Connections between the Mirage servers and storage should be dedicated/segregated, high-speed (LAN) connections, preferably 10 Gigabit Ethernet.

- **Mirage server and clients** – Connection speeds between clients and servers vary depending on the location of endpoints, available bandwidth, network latency, and other network-limiting factors.

- **Mirage Management server, Mirage server, Mirage file and Web portals** – Connections between the Mirage system components require high-speed LAN connections and were installed within the same data center.
Figure 3 presents an overview of the design of this reference architecture.

The health, capacity, and performance of the network all affect Mirage. The network can delay or disrupt backups, OS deployment, and Windows migrations if not designed properly. As part of the project planning and assessment, the following network-related information was carefully gathered and reviewed, as it should be for future implementations based on this reference architecture:

- Network topology, including all circuit speeds, types, current level of utilization and latency, endpoint distribution, and MTU sizes.
- Implementation of any WAN acceleration, traffic shaping, Quality of Service (QoS), Class of Service (CoS), or priority queuing.
- Endpoint connectivity methods (LAN, WAN, VPN, or Internet).

For information on deployments involving remote offices, see the Mirage Branch Office Reference Architecture.

The Mirage server infrastructure is located in the customer’s primary data center, supported by Gigabit Ethernet for applications and server-to-server communication, and by 10 Gigabit Ethernet for storage connectivity.

The customer’s firewalls and intrusion prevention and detection infrastructure had to be configured to support Mirage. The default TCP/IP ports required are listed in Table 2, where external refers to communication between the Mirage system and endpoints, and internal ports are used for communications between the Mirage Management server, Mirage servers, the file portal, and supporting infrastructure, including storage, Active Directory (AD), and Domain Name Service (DNS).
<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>COMMUNICATION</th>
<th>PORT</th>
<th>PROTOCOL</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mirage server service</td>
<td>External</td>
<td>8000</td>
<td>TCP</td>
<td>The only port required for communications between Mirage clients and Mirage servers. SSL/TLS is optional.</td>
</tr>
<tr>
<td>Mirage Management service</td>
<td>External</td>
<td>8443</td>
<td>TCP</td>
<td>Used for communication between Mirage Management console and Mirage Management service. SOAP message-level security applied.</td>
</tr>
<tr>
<td>Mirage server service</td>
<td>Internal</td>
<td>135, 445</td>
<td>TCP/UDP</td>
<td>Used for control communication between the Mirage Management service and the Mirage server. You can limit access to this port to incoming connections from the Mirage Management service host.</td>
</tr>
<tr>
<td>File portal</td>
<td>Internal</td>
<td>8444</td>
<td>TCP</td>
<td>Used for communication between the IIS server and the Mirage Management server.</td>
</tr>
<tr>
<td>File portal</td>
<td>External</td>
<td>80 or 443</td>
<td>TCP</td>
<td>Access to Web-based file/folder recovery portal. HTTPS (SSL) access is optional.</td>
</tr>
<tr>
<td>Web administration</td>
<td>Internal</td>
<td>8443</td>
<td>TCP</td>
<td>Used for communication between the IIS server and the Mirage Management server.</td>
</tr>
<tr>
<td>Web administration</td>
<td>External</td>
<td>80 or 443</td>
<td>TCP</td>
<td>Access to Web-based administration portal. HTTPS (SSL) access is optional.</td>
</tr>
</tbody>
</table>

Table 2: Configuration of Mirage Network Ports

Storage Considerations and Configuration

Mirage requires storage volumes to store base layers, application layers, hardware drivers, and endpoint backups. It is important to design the storage for Mirage properly to provide both for sufficient capacity and for storage IOPS. Mirage can use local storage or network storage shared via CIFS/SMB. If multiple Mirage servers are deployed in a cluster, use of CIFS/SMB file shares is recommended. Mirage does not support the use of direct-attached storage.

Mirage storage performance is affected by the speed and health of the network between the endpoints and the Mirage infrastructure and by the number of simultaneous endpoint operations performed. The faster data moves to the Mirage server, the faster the information can be written to disk, if the storage system can support it. If the storage does not have sufficient IOPS, Mirage throttles its operations, slowing them down to accommodate available IOPS on the storage system.
When you plan centralization time for groups of endpoints, remember that an endpoint cannot be centralized if it is not online, even with proper infrastructure resources in place. Policies to turn PCs off after a period of inactivity, and power management configurations that turn them off, reduce the connectivity time and increase the centralization time. This applies to mobile as well as stationary endpoints.

As suggested in Figure 4, any reduction in connectivity time affects both the time needed for centralization and network bandwidth utilization. Any increase in connectivity time reduces centralization time but also requires greater utilization of network bandwidth.

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As suggested in Figure 4, any reduction in connectivity time affects both the time needed for centralization and network bandwidth utilization. Any increase in connectivity time reduces centralization time but also requires greater utilization of network bandwidth.

The storage configuration summarized in Table 3 was designed to provide sufficient IOPS and capacity for the first series of remote endpoints.

<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>DESCRIPTION</th>
<th>STORAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mirage Single-Instance Storage (SIS)</td>
<td>12.5TB on a dedicated RAID-10 NFS volume hosted by an HP StoreEasy 3826-based storage appliance optimized for write caching, providing 22,000 write IOPS. The RAID-10 volume was connected to a Windows 2008 R2 File Server that shared it with the Mirage system via CIFS/SMB.</td>
</tr>
<tr>
<td>1</td>
<td>Mirage server local cache</td>
<td>103GB VMDK stored on PCIe-based SSD storage installed on an ESXi host, providing more than 40,000 write IOPS.</td>
</tr>
</tbody>
</table>

Table 3: Mirage Storage Configuration
External Infrastructure Components

Mirage relies on specific infrastructure services that must be available in the data centers where it is deployed.

• **Active Directory (AD)** – Mirage uses Microsoft Windows 2008 or 2012 AD for authentication and policy management purposes.

• **Domain Name Service (DNS)** – Mirage relies on proper DNS name resolution to be able to communicate with the various infrastructure components and the managed endpoints.

• **Network Time Protocol (NTP)** – Although NTP services are not explicitly required for a Mirage installation, making sure that critical systems use time synchronization is a best practice. Be sure to configure NTP properly for all major infrastructure components, including servers, network equipment, storage appliances, virtual machines, and AD controllers.

Endpoint Centralization

After the Mirage infrastructure was implemented, the first step in preparing the initial endpoints for Windows 7 migration was to back up each desktop. This preserved critical user data and provided a way to recover in case of failed migrations. Unlike competing migration solutions, such as Microsoft SCCM, Mirage centralization provides a complete desktop backup and disaster recovery solution.

By design, Mirage backs up not only the unique user data on each desktop, but also what would be required to restore each system’s unique configuration, including user personalization and applications, to the same or different hardware. This gives the customer not just a way to recover from failed migrations, but an ongoing system to protect critical user data and personalized desktops if they are ever lost or broken.

The desktop assessment performed as part of the migration planning process revealed that the 800 desktops in the corporate office used a total of 28TB of disk space. However, each had an average of only 28 percent unique content, including user data and applications. The remaining 72 percent consisted of duplicate data and applications, including Windows XP. With Mirage, this duplicate content needs to be backed up only once before Mirage optimizes the centralization process with deduplication. To jumpstart the ability of Mirage to deduplicate LAN-based systems, five Windows XP SP3 desktops running typical customer applications were centralized in the data center first. This relieved Mirage of having to transfer copies of Windows XP, Office XP, and other applications across the LAN multiple times.

![Figure 5: Desktop Centralization](image-url)
Test Results: Centralization over Typical LAN

To provide guidance for backing up endpoints located in a LAN, the endpoints used in all the migration tests were centralized over a Gigabit LAN circuit. This enabled measuring the change in time and Mirage system resources required to centralize the endpoints as the circuit speed stayed the same.

Total Centralization Time

To accurately measure the resource requirements for Mirage centralization, it is important to understand the difference between sustained utilization time, upload manifest time, and total centralization time.

Sustained utilization time is the time during which Mirage centralization actively consumes system resources. It includes only those times when at least 25 endpoints are being centralized.

Upload manifest time begins when the administrator clicks the Finish button of the Centralize Endpoint wizard and ends when the first endpoint starts sending information to the Mirage server.

Total centralization time begins when the administrator clicks the Finish button of the Centralize Endpoint wizard and ends when all endpoints complete centralization.

Table 4 shows the centralization time for different numbers of desktops being centralized, the average amount of disk saving, and the upload manifest time for each test.

<table>
<thead>
<tr>
<th>NUMBER OF ENDPOINTS</th>
<th>SUSTAINED UTILIZATION TIME</th>
<th>UPLOAD MANIFEST TIME</th>
<th>TOTAL CENTRALIZATION TIME</th>
<th>% DISK SAVING</th>
<th>TOTAL DATA TRANSFERRED</th>
<th>TOTAL DATA ON ENDPOINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1 hour 17 minutes</td>
<td>3 minutes</td>
<td>1 hour 20 minutes</td>
<td>73.6%</td>
<td>18.6GB</td>
<td>70.0GB</td>
</tr>
<tr>
<td>25</td>
<td>4 hours 8 minutes</td>
<td>9 minutes</td>
<td>4 hours 17 minutes</td>
<td>76.5%</td>
<td>92.9GB</td>
<td>349.8GB</td>
</tr>
<tr>
<td>50</td>
<td>7 hours 54 minutes</td>
<td>21 minutes</td>
<td>8 hours 15 minutes</td>
<td>30.4%</td>
<td>487GB</td>
<td>696GB</td>
</tr>
<tr>
<td>100</td>
<td>33 hours 9 minutes</td>
<td>4 hours 2 minutes</td>
<td>37 hours 11 minutes</td>
<td>35.0%</td>
<td>926GB</td>
<td>1.41TB</td>
</tr>
<tr>
<td>250</td>
<td>53 hours 26 minutes</td>
<td>5 hours 36 minutes</td>
<td>59 hours 2 minutes</td>
<td>28.9%</td>
<td>2.53TB</td>
<td>3.52TB</td>
</tr>
<tr>
<td>400</td>
<td>69 hours 15 minutes</td>
<td>6 hours 59 minutes</td>
<td>76 hours 14 minutes</td>
<td>28.1%</td>
<td>3.96TB</td>
<td>5.47TB</td>
</tr>
<tr>
<td>800</td>
<td>87 hours 32 minutes</td>
<td>8 hours 22 minutes</td>
<td>95 hours 54 minutes</td>
<td>28.6%</td>
<td>8.01TB</td>
<td>11.2TB</td>
</tr>
</tbody>
</table>

Table 4: Endpoint Centralization Time
As shown in Table 4, the percentage of disk saving varies for each test because each physical desktop in the environment contains a different amount of unique data. For example, some users had 9GB of unique data, others had 16GB, but on average, the amount of unique data was approximately 10GB. In general, a larger test yields a more accurate sampling. Based on this environment (Windows XP SP3, Office 2007, and a few other applications), Mirage deduplication enabled an average disk savings of 28-30 percent. The smaller tests were not used to calculate the average.

In the largest scenario, Mirage centralized all 800 endpoints over the Gigabit LAN in a period of three days, 23 hours, and 54 minutes, **against a single Mirage server**. Working on a larger scale, adding additional Mirage servers shortens the centralization time even more. However, it is critically important to have proper planning of available resources to support the addition of those Mirage servers. Simply augmenting the number of servers can minimize the total time for centralization, but it also puts an additional workload on the network and storage resources. It is also important to consider the total time that endpoints are expected be online every day.

![Centralization Time](image)

**Figure 6: Resources to Consider when Adding Mirage Servers**

Between deduplication and compression, Mirage was able to achieve an average savings of 30 percent. This means that only 70 percent of the content of the 800 endpoints, 19.6TB of the 28TB total, had to be transferred across the LAN. This slashed both the time and bandwidth that would have been needed to back the desktops up without these key capabilities.

Mirage servers are built to sustain close to 100 percent utilization for a long period of time without causing issues for endpoints or servers in the environment. They can run a large number of concurrent operations for multiple days at full capacity. When running at full capacity, Mirage servers throttle endpoint transfer speed as needed, which makes this a good solution for managing thousands of endpoints. As more storage resources become available, Mirage servers allow the endpoints to increase their file transfer speed.
To check the average transfer speed of any endpoint after it finishes centralizing, look at the transaction log in the Mirage Management console. Find an endpoint that has finished centralizing, right-click, and choose properties. The average transfer speed for endpoints varies considerably, sometimes by as much as several MB/s. In this customer’s case, the best transfer speed was 2.6MB/s per endpoint. Figure 7 shows two examples of this data.

Another built-in network functionality in the Mirage server is throttling. Mirage limits the amount of parallel data deduplication to avoid overloading the storage. Mirage pauses endpoints to temporarily keep them from transferring data so that once an endpoint completes deduplication, the next machine continues its transfer. The Mirage server performs throttling automatically and resumes the transfer as soon as bandwidth becomes available again.

You can look at throttling in the Mirage Management console when a large number of concurrent endpoints are centralizing. For instance, in one of the scenarios detailed in Table 4, there was endpoint throttling in the concurrent centralization of 100, 250, 400, and 800 endpoints. Because the actual number of throttled endpoints varies and is automatically managed by Mirage, no data was captured for this event, but it could be seen briefly in the console, as shown in Figure 8.

As soon as the deduplication process was complete on the endpoints, the Mirage server stopped throttling those endpoints, and centralization continued. This was 100 percent transparent to the end user.
Endpoint Centralization: Resource Consumption

In addition to LAN bandwidth, the Mirage system required sustained utilization of the following resources during centralization:

- Mirage server CPU
- CIFS Storage server CPU
- Mirage CIFS Storage (SIS) IOPS
- Mirage server local cache IOPS

<table>
<thead>
<tr>
<th>NUMBER OF DESKTOPS</th>
<th>CPU UTILIZATION MIRAGE SERVER (% OF 6 VCPUS)</th>
<th>CPU UTILIZATION CIFS STORAGE SERVER (% OF 2 CPUS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AVERAGE</td>
<td>PEAK</td>
</tr>
<tr>
<td>50</td>
<td>70.28%</td>
<td>89.83%</td>
</tr>
<tr>
<td>100</td>
<td>80.24%</td>
<td>93.97%</td>
</tr>
<tr>
<td>250</td>
<td>79.33%</td>
<td>96.97%</td>
</tr>
<tr>
<td>400</td>
<td>81.09%</td>
<td>94.88%</td>
</tr>
</tbody>
</table>

Table 5: Mirage Server and Storage Server CPU Utilization Summary by Number of Endpoints

<table>
<thead>
<tr>
<th>NUMBER OF DESKTOPS</th>
<th>MIRAGE SERVER LOCAL CACHE</th>
<th>MIRAGE CIFS STORAGE (SIS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>READ IOPS</td>
<td>WRITE IOPS</td>
</tr>
<tr>
<td></td>
<td>AVERAGE</td>
<td>PEAK</td>
</tr>
<tr>
<td>50</td>
<td>54.59</td>
<td>174.50</td>
</tr>
<tr>
<td>100</td>
<td>96.3</td>
<td>131.7</td>
</tr>
<tr>
<td>250</td>
<td>52.87</td>
<td>133.44</td>
</tr>
<tr>
<td>400</td>
<td>47.97</td>
<td>102.92</td>
</tr>
</tbody>
</table>

Table 6: Mirage Server Local Cache and CIFS Storage IOPS Summary by Number of Endpoints

The resource utilization averages in these tables confirm that the Mirage infrastructure can support a large number of concurrent operations, and that the Mirage server throttles its operation based on available resources. Similarly, faster networks decrease the time required for centralization, but they also increase the amount of resources needed for Mirage to handle faster endpoint communication.

Differences in endpoints and how they are used can also impact centralization time and the system resources required. All the desktops centralized in this project were online 24 hours per day and did not have active users or applications. By design, Mirage minimizes its impact on end-user productivity, throttling client activity by as much as a factor of 10 if it detects the endpoint is in use.
All the endpoints centralized had the same hardware configuration and were automatically defragmented. Differences in the age and performance of the hardware, the amount of unique data, and the number of hours per day each endpoint is online and actively used all impact the amount of time required for Mirage to back them up. Such factors are best evaluated by performing a comprehensive assessment of the desktops as part of Windows 7 migration planning. Typically, Mirage is not permitted to use the entire circuit in order to save bandwidth for other applications. When planning your migration, consult the test results for the network speed that most closely matches the amount of bandwidth Mirage is permitted to use.

The endpoints during these tests were also online 24 hours per day with no active users. They also had the same hardware configuration, with hard disks that were automatically defragmented using Raxco PerfectDisk. Centralization of desktops that are not online as much, have active users, or differing hardware configurations or levels of system health require different amounts of time and Mirage resources. Performing an assessment of the endpoints to be centralized can help identify such factors.
Test Results: Windows 7 Migration of 825 Endpoints over LAN

This section describes the migration of up to 400 concurrent endpoints to Microsoft Windows 7.

Using the Windows OS Migration wizard in the Mirage Management console, the administrator selected the first five Windows XP desktops that completed centralization. Because the endpoints had been backed up by Mirage centralization, the administrator had an easy way to fully recover any endpoint whose migration did not succeed.

Before completing the wizard and launching the migration, the administrator selected the Windows 7 base layer, AD domain, and organizational unit (OU) for the desktops.

The desktops remained completely available while the Mirage server transferred Windows 7 to each endpoint, in the background. Only after Windows 7 was completely transferred to each endpoint did the migration from XP actually begin. These desktops did not have active users at the time, so Mirage automatically rebooted them to begin the migration. If any users had been logged in to any of the endpoints, they would have been prompted to reboot, giving them an opportunity to save open work and continue, or to delay their migration.

During the reboot, Mirage replaced Windows XP with the Windows 7 base layer in an operation known as the pivot. It then rebooted again, starting Windows 7 for the first time, performing hardware detection and installation of the drivers from the Mirage driver library. During this time, Mirage displayed a series of screens similar to the image in Figure 9.

![Figure 9: Example of a Mirage “Do not turn off...” Message](image)

After driver installation and other required tasks were completed, the endpoints were added to the AD domain, and the users’ Windows profile and data were migrated automatically from Windows XP. The desktop then booted a final time, fully migrated to Windows 7 and available for use, with an average total amount of downtime of only 26 minutes!

The following tables show the migration time for different numbers of endpoints, ranging from 10 to 400 concurrent operations. Even with the increase in the total number of concurrent endpoints being migrated, the total amount of time to complete the migration did not increase at the same rate. This was due mainly to Mirage server local cache technology, which leverages the local server cache during the push of the Windows 7 base image to the various endpoints. Because the same image is sent to all endpoints, Mirage does not have to go back to the Single-Instance Storage (SIS) every time. After the initial image is sent to the endpoints, Mirage retains the information in its local cache.
<table>
<thead>
<tr>
<th>Table 7: Time Required to Migrate 10 Endpoints to Windows 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time required to transfer Windows 7 to all endpoints</td>
</tr>
<tr>
<td>Time required to complete migration on all endpoints</td>
</tr>
<tr>
<td>Average endpoint downtime (user interrupted)</td>
</tr>
<tr>
<td>Total migration time for all 10 endpoints</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 8: Time Required to Migrate 25 Endpoints to Windows 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time required to transfer Windows 7 to all endpoints</td>
</tr>
<tr>
<td>Time required to complete migration on all endpoints</td>
</tr>
<tr>
<td>Average endpoint downtime (user interrupted)</td>
</tr>
<tr>
<td>Total migration time for all 25 endpoints</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 9: Time Required to Migrate 50 Endpoints to Windows 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time required to transfer Windows 7 to all endpoints</td>
</tr>
<tr>
<td>Time required to complete migration on all endpoints</td>
</tr>
<tr>
<td>Average endpoint downtime (user interrupted)</td>
</tr>
<tr>
<td>Total migration time for all 50 endpoints</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 10: Time Required to Migrate 100 Endpoints to Windows 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time required to transfer Windows 7 to all endpoints</td>
</tr>
<tr>
<td>Time required to complete migration on all endpoints</td>
</tr>
<tr>
<td>Average endpoint downtime (user interrupted)</td>
</tr>
<tr>
<td>Total migration time for all 100 endpoints</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 11: Time Required to Migrate 250 Endpoints to Windows 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time required to transfer Windows 7 to all endpoints</td>
</tr>
<tr>
<td>Time required to complete migration on all endpoints</td>
</tr>
<tr>
<td>Average endpoint downtime (user interrupted)</td>
</tr>
<tr>
<td>Total migration time for all 250 endpoints</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 12: Time Required to Migrate 400 Endpoints to Windows 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time required to transfer Windows 7 to all endpoints</td>
</tr>
<tr>
<td>Time required to complete migration on all endpoints</td>
</tr>
<tr>
<td>Average endpoint downtime (user interrupted)</td>
</tr>
<tr>
<td>Total migration time for all 400 endpoints</td>
</tr>
</tbody>
</table>
During the migration process, Mirage monitored the following resources for performance. These resources had sustained utilization:

- Local area network
- Mirage server CPU
- Mirage server read and write IOPS
- Mirage local cache read and write IOPS

As noted, once the migration begins and the reference image is transferred to the Mirage server’s local cache, there is not a lot of activity going back to the Mirage SIS. The fact that the Mirage server keeps the information in its local cache is a good reason to put the local cache on very fast storage, such as SSD, when possible. The following tables list the resource utilization figures for each migration done from Tables 7–12.

<table>
<thead>
<tr>
<th>NUMBER OF DESKTOPS</th>
<th>CPU UTILIZATION</th>
<th>MIRAGE SERVER (%) OF 8 vCPUS</th>
<th>CPU UTILIZATION</th>
<th>CIFS STORAGE SERVER (%) OF 2 CPUS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AVERAGE</td>
<td>PEAK</td>
<td>AVERAGE</td>
<td>PEAK</td>
</tr>
<tr>
<td>10</td>
<td>14.70%</td>
<td>41.90%</td>
<td>1.30%</td>
<td>2.77%</td>
</tr>
<tr>
<td>25</td>
<td>27.90%</td>
<td>70.00%</td>
<td>3.25%</td>
<td>6.93%</td>
</tr>
<tr>
<td>50</td>
<td>38.10%</td>
<td>85.00%</td>
<td>6.51%</td>
<td>13.90%</td>
</tr>
<tr>
<td>100</td>
<td>47.50%</td>
<td>95.90%</td>
<td>17.40%</td>
<td>27.95%</td>
</tr>
<tr>
<td>250</td>
<td>58.90%</td>
<td>96.90%</td>
<td>21.50%</td>
<td>31.65%</td>
</tr>
<tr>
<td>400</td>
<td>65.90%</td>
<td>97.60%</td>
<td>24.85%</td>
<td>43.20%</td>
</tr>
</tbody>
</table>

Table 13: CPU Utilization Summary by Number of Desktops

<table>
<thead>
<tr>
<th>NUMBER OF DESKTOPS</th>
<th>MIRAGE SERVER LOCAL CACHE</th>
<th>MIRAGE CIFS STORAGE (SIS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>READ IOPS</td>
<td>WRITE IOPS</td>
</tr>
<tr>
<td></td>
<td>AVERAGE</td>
<td>PEAK</td>
</tr>
<tr>
<td>10</td>
<td>0.23</td>
<td>63.45</td>
</tr>
<tr>
<td>25</td>
<td>0.46</td>
<td>71.25</td>
</tr>
<tr>
<td>50</td>
<td>0.67</td>
<td>89.10</td>
</tr>
<tr>
<td>100</td>
<td>1.35</td>
<td>120.40</td>
</tr>
<tr>
<td>250</td>
<td>1.68</td>
<td>167.25</td>
</tr>
<tr>
<td>400</td>
<td>4.96</td>
<td>244.35</td>
</tr>
</tbody>
</table>

Table 14: I/O Summary by Local Cache and Mirage CIFS
Conclusion

This reference architecture demonstrates that VMware Mirage enabled the customer to

• Eliminate the need to dispatch IT to migrate desktops manually.
• Save time, resources, and user productivity.
• Make it possible to migrate remote endpoints to Windows 7 on a scale that would not be practical otherwise.

In this case, after completing a comprehensive assessment, the customer was able to centralize 800 endpoints in less than four days using a single Mirage server. Migration of up to 400 concurrent desktops took just over five and a half hours. IT intervention was not required except to launch the migration and inspect the systems upon completion. The average endpoint downtime during the complete Windows XP to Windows 7 migration was only 26 minutes, which translated to only a minimal interruption of user productivity.

If you are considering a large-scale deployment of Mirage, we recommend that you engage technical resources, such as VMware Professional Services or a certified partner, early in the planning process. VMware can make a variety of resources available to you, from product documentation, case studies, and technical papers, to access to people with hands-on experience in centralizing and migrating large numbers of desktops.

About the Authors

Stephane Asselin is a Senior Architect on the VMware End-User Computing Technical Enablement team. He has been involved in desktop deployments for over 17 years and has extensive field experience with VMware End-User Computing and ecosystem products.

Chris White is an Architect on the VMware End-User Computing Technical Enablement team. Over the past 18 years, he has worked in many areas of virtualization and was recently responsible for the design and implementation of a very large-scale deployment of Horizon View.

To comment on this paper, contact the VMware End-User Computing Solutions Management and Technical Marketing team at twitter.com/vmwarehorizon.

Acknowledgments

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• Alex Hahn, Hewlett-Packard Technical Consultant
• Oded Sapir, Scale Testing Engineer, VMware Mirage Research and Development Group
• Shai Carlos Tsukroon, Senior Quality Engineer, VMware Mirage Research and Development Group
References

Horizon Branch Office Desktop
VMware Compatibility Guide
VMware Mirage Branch Office Reference Architecture
VMware Mirage Community
VMware Mirage Documentation
  • Installation Guide
  • Administrator’s Guide
  • Web Manager Guide
  • Image Management for View Desktops using VMware Mirage
  • VMware Mirage 5.0 Release Notes
  • Release Notes
VMware Mirage Download
VMware Mirage Product Evaluation Center
Appendix A: Reference Architecture Detail

The various elements in this reference architecture are summarized in the following tables:

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| Mirage Management server | • 8 vCPUs  
                   | • 16GB of RAM  
                   | • 40GB of hard disk  
                   | • Mirage 5.0  
                   | • Windows Server 2008 R2 SP1 |
| Mirage server      | • 8 vCPUs  
                   | • 16GB of RAM  
                   | • 40GB of hard disk for OS  
                   | • 103GB for local cache  
                   | • Mirage 5.0  
                   | • Windows Server 2008 R2 SP1 |
| SQL Server         | • Dual vCPUs  
                   | • 8GB of RAM  
                   | • 40GB of hard disk for OS  
                   | • Windows Server 2008 R2 SP1  
                   | • MS SQL Server 2008 R2 – Enterprise Edition |
| Active Directory server | • Dual vCPUs  
                   | • 8GB of RAM  
                   | • 40GB of hard disk for OS  
                   | • Windows Server 2008 R2 SP1 |

Table 15: Server Components

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| Mirage endpoints   | • Intel Pentium Dual Core E2160, 1.80GHz, 1MB L2 cache 8GB of RAM  
                   | • 80GB of hard disk for OS  
                   | • Windows XP SP3 and Office 2007 SP3  
                   | • Miscellaneous applications (Adobe Reader, Java, etc.) |

Table 16: Endpoints (Desktops)
<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical vSphere host for Mirage server hosting</td>
<td>• Four (4) BL460c Gen8&lt;br&gt;• Intel Xeon E5-2670 (2.60GHz/8-core/20MB/115W) Processor Kit&lt;br&gt;• BLC VC 8GB FC 24-Port Option Kit&lt;br&gt;• 2400W High-Efficiency Power Supply&lt;br&gt;• ProLiant BL460c Gen8 10Gb&lt;br&gt;• 300GB 2.5&quot; Internal Hard Drive – SAS – 10000RPM – Hot Pluggable&lt;br&gt;• Memory – 16GB – DIMM 240-pin – DDR3 – 1600MHz / PC3-12800 – CL11 – registered – ECC&lt;br&gt;• Flex-10 10Gb 2-port 530FLB Adapter – network adapter – 2 ports&lt;br&gt;• BladeSystem c-Class 10Gb Short Range Small Form-Factor Pluggable Option&lt;br&gt;• 256GB RAM total per host&lt;br&gt;• VMware ESXi 5.5.0, Build 1331820&lt;br&gt;• VMware vCenter™ Server 5.5.0 Build 1312298</td>
</tr>
</tbody>
</table>

Table 17: vSphere Infrastructure

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance measurement</td>
<td>• Cacti graphing solution 0.8.8b&lt;br&gt;• RRDTOol 1.3&lt;br&gt;• SNMP Informant</td>
</tr>
<tr>
<td>vSphere monitoring</td>
<td>• vSphere Log Insight 1.0.4-1169900&lt;br&gt;• VMware vCenter Operations Manager 5.7.2 Build 1314472</td>
</tr>
</tbody>
</table>

Table 18: Infrastructure Monitoring
Appendix B: Mirage Server Recommendations for Mass Centralization

The Mirage server is designed to handle a high volume of concurrent operations, given proper resources—CPU, memory, network bandwidth, and storage IOPS—to support the workloads. Endpoint centralization is the operation that consumes the largest amount of resources. When starting a large-scale Mirage project, if the intent is to quickly centralize all the endpoints, whether to back them up or to start your migration, plan to scale-out your infrastructure for that time period, until the initial mass centralization phase is complete.

Initial Mass Centralization

Scale out to accommodate concurrent uploads

This reference architecture demonstrates that one Mirage server can accommodate the synchronization of a large number of endpoints. The server reached maximum resource utilization at around 100 concurrent operations. If you want to minimize that initial mass centralization time, adding more Mirage servers is the best approach. However, if multiple Mirage servers are deployed in your organization, you need to place a load balancer in front of your Mirage servers and use the FQDN of the load-balanced environment to deploy to the endpoints. Mirage servers are easy to deploy and work extremely well in a virtualized environment. You are encouraged to run them on virtual infrastructures.

Elastic Infrastructure

Mirage servers are stateless — run great as virtual machines

Deploying multiple Mirage servers this way, you can provision more servers as needed and phase them out once the initial mass centralization phase is complete.

On average, an endpoint centralized with Mirage consumes about 15kb/s over a period of 24 hours. This is important because after all the endpoints are centralized, the delta of information continues to sync back to the Mirage server. That 15kb/s, although very small, could add up to a fair amount of continuous data exchanged when multiplied by hundreds or thousands of machines. VMware Professional Services has a Mirage centralization calculator that can help you estimate the time it might take to complete the initial mass centralization. For more information, contact your VMware account team or VMware partner.
Appendix C: Mirage Centralization Workflow

Figure 10 is a logical representation of the high-level steps of a Mirage centralization process.
Appendix D: Mirage Windows 7 Migration Workflow

Figure 11 is a logical representation of the high-level steps of a Mirage migration process. In this workflow, after the endpoint migration is complete, it is a good idea to archive the old image in case an end user needs to go back to the previous operating system for any reason.

Figure 11: Mirage Migration Workflow