

Horizon 7 Architecture Planning

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VMware Horizon 7 7.6



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Horizon 7 Architecture Planning

Horizon 7 Architecture Planning provides an introduction to VMware Horizon™ 7, including a description of its major features and deployment options and an overview of how the components are typically set up in a production environment.

This guide answers the following questions:

- Does the product solve the problems you need it to solve?
- Would it be feasible and cost-effective to implement this solution in your enterprise?

Not all features and capabilities of VMware Horizon 7 are available in all editions. For a comparison of feature sets in each edition, see

<http://www.vmware.com/files/pdf/products/horizon-view/VMware-Horizon-View-Pricing-Licensing-FAQ.pdf>.

To help you protect your installation, this guide also provides a discussion of security features.

Intended Audience

This information is intended for IT decision makers, architects, administrators, and others who need to familiarize themselves with the components and capabilities of this product. With this information, architects and planners can determine whether Horizon 7 satisfies the requirements of their enterprise for efficiently and securely delivering Windows desktops and applications to their end users. The example architecture helps planners understand the hardware requirements and setup effort required for a large-scale deployment.

Introduction to Horizon 7

With Horizon 7, IT departments can run remote desktops and applications in the data center and deliver these desktops and applications to employees as a managed service. End users gain a familiar, personalized environment that they can access from any number of devices anywhere throughout the enterprise or from home. Administrators gain centralized control, efficiency, and security by having desktop data in the data center.

This chapter includes the following topics:

- [Advantages of Using Horizon 7](#)
- [Horizon 7 Features](#)
- [How the Components Fit Together](#)
- [Integrating and Customizing Horizon 7](#)

Advantages of Using Horizon 7

When you manage enterprise desktops with Horizon 7, the benefits include increased reliability, security, hardware independence, and convenience.

Reliability and Security

Desktops and applications can be centralized by integrating with VMware vSphere[®] and virtualizing server, storage, and networking resources. Placing desktop operating systems and applications on a server in the data center provides the following advantages:

- Access to data can easily be restricted. Sensitive data can be prevented from being copied onto a remote employee's home computer.
- RADIUS support provides flexibility when choosing among two-factor authentication vendors. Supported vendors include RSA SecureID, VASCO DIGIPASS, SMS Passcode, and SafeNet, among others.
- Integration with VMware Identity Manager means that end users have on-demand access to remote desktops through the same Web-based application catalog they use to access SaaS, Web, and Windows applications. Inside a remote desktop, users can also use this custom app store to access applications.

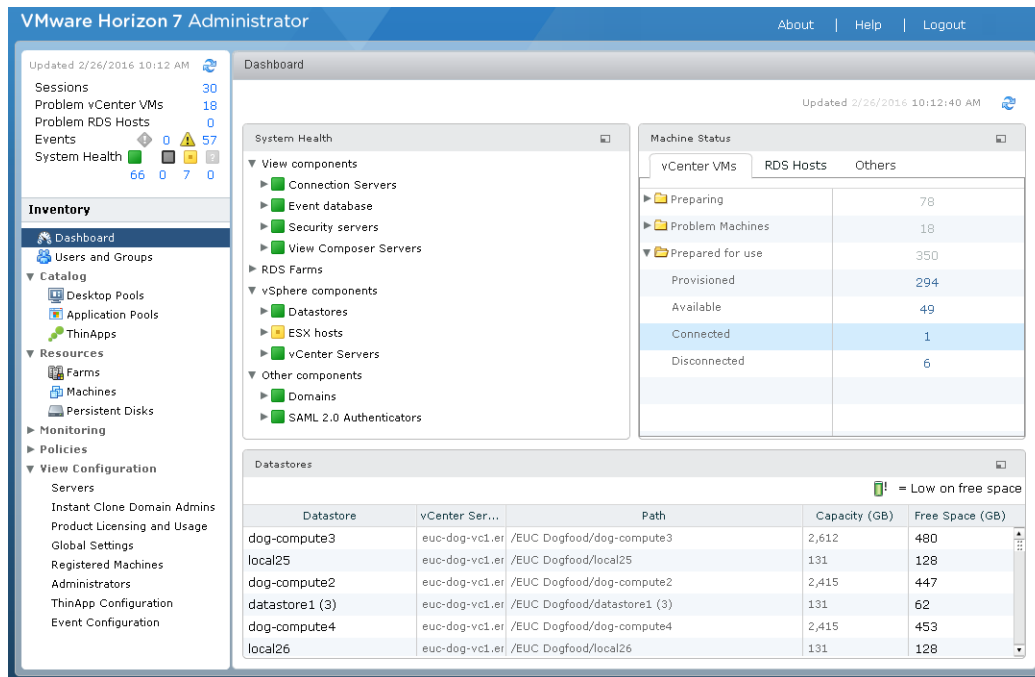
- The ability to provision remote desktops with pre-created Active Directory accounts addresses the requirements of locked-down Active Directory environments that have read-only access policies.
- Data backups can be scheduled without considering when end users' systems might be turned off.
- Remote desktops and applications that are hosted in a data center experience little or no downtime. Virtual machines can reside on high-availability clusters of VMware servers.

Virtual desktops can also connect to back-end physical systems and Microsoft Remote Desktop Services (RDS) hosts.

Convenience

The unified management console is built for scalability so that even the largest Horizon 7 deployments can be efficiently managed from a single management interface. Wizards and dashboards enhance the workflow and facilitate drilling down to see details or change settings. [Figure 1-1](#) provides an example of the browser-based user interface for Horizon Administrator.

Figure 1-1. Administrative Console Showing the Dashboard View



Other features that increase convenience are the VMware remote display protocols, PCoIP (PC over IP) and Blast Extreme. These display protocols deliver an end-user experience equal to the current experience of using a physical PC:

- On LANs, the display is faster and smoother than traditional remote displays.
- On WANs, the display protocols can compensate for an increase in latency or a reduction in bandwidth, ensuring that end users can remain productive regardless of network conditions.

Manageability

Provisioning desktops and applications for end users is a quick process. No one is required to install applications one by one on each end user's physical PC. End users connect to a published application or a remote desktop complete with applications. End users can access their same remote desktop or application from various devices at various locations.

Using VMware vSphere to host virtual desktops and RDS host servers provides the following benefits:

- Administration tasks and management chores are reduced. Administrators can patch and upgrade applications and operating systems without touching a user's physical PC.
- Integration with VMware Identity Manager means that IT managers can use the Web-based VMware Identity Manager administration interface to monitor user and group entitlements to remote desktops.
- Integration with VMware App Volumes, a real-time application delivery system, enables enterprises to deliver and manage applications at scale. Use App Volumes to attach applications to users, groups, or target computers, even when users are logged into their desktop. Applications can also be provisioned, delivered, updated and retired in real time.
- With Horizon Persona Management, physical and virtual desktops can be centrally managed, including user profiles, application entitlement, policies, performance, and other settings. Deploy Persona Management to physical desktop users prior to converting to virtual desktops.
- With VMware User Environment Manager, end users get a personalized Windows desktop that is adapted to the user's situation, meaning that access to the required IT resources is based on aspects such as role, device, and location.
- Storage management is simplified. Using VMware vSphere, you can virtualize volumes and file systems to avoid managing separate storage devices.
- With vSphere 6.0 or a later release, you can use Virtual Volumes (VVols). This feature maps virtual disks and their derivatives, clones, snapshots, and replicas, directly to objects, called virtual volumes, on a storage system. This mapping allows vSphere to offload intensive storage operations such as snapshotting, cloning, and replication to the storage system. For example, a cloning operation that previously took an hour might now take just a few minutes using Virtual Volumes.
- With vSphere 5.5 Update 1 or a later release, you can use vSAN, which virtualizes the local physical solid-state disks and hard disk drives available on ESXi™ hosts into a single datastore shared by all hosts in a cluster. You specify only one datastore when creating a desktop pool, and the various components, such as virtual machine files, replicas, user data, and operating system files, are placed on either SSD disks or hard drive disks, as appropriate.

You manage virtual machine storage requirements, such as capacity, performance, and availability, in the form of default storage policy profiles, which get created automatically when you create a desktop pool.

- With the Horizon 7 storage accelerator, the IOPS storage load is dramatically reduced, supporting end-user logins at larger scales without requiring any special storage array technology.

- If remote desktops use the space-efficient disk format available with vSphere 5.1 and later, stale or deleted data within a guest operating system is automatically reclaimed with a wipe and shrink process.

Hardware Independence

Remote desktops and published applications are hardware-independent. For example, because a remote desktop runs on a server in the data center and is only accessed from a client device, a remote desktop can use an operating system that might not be compatible with the hardware of the client device.

Remote desktops run on PCs, Macs, thin clients, and PCs that have been repurposed as thin clients, tablets, and phones. The published applications run on a subset of these devices. New device support is added quarterly.

If you use the HTML Access feature, end users can open a remote desktop or application inside a browser, without having to install any client application on the client system or device.

Horizon 7 Features

Features included in Horizon 7 support usability, security, centralized control, and scalability.

The following features provide a familiar experience for the end user:

- On certain client devices, print from a virtual desktop to any local or networked printer that is defined on the client device. This virtual printer feature solves compatibility issues and does not require you to install additional print drivers in a virtual machine.
- On most client devices, use the location-based printing feature to map to printers that are physically near the client system. Location-based printing does require that you install print drivers in the virtual machine.
- Local printer redirection is designed for the following use cases:
 - Printers directly connected to USB or serial ports on the client
 - Specialized printers such as bar code printers and label printers connected to the client
 - Network printers on a remote network that are not addressable from the virtual session.
- Use multiple monitors. With the PCoIP and Blast Extreme display protocols, multiple-monitor support means you can adjust the display resolution and rotation separately for each monitor.
- Access USB devices and other peripherals that are connected to the local device that displays your virtual desktop.

You can specify which types of USB devices end users are allowed to connect to. For composite devices that contain multiple types of devices, such as a video input device and a storage device, you can split the device so that one device (for example, the video input device) is allowed but the other device (for example, the storage device) is not.

- Use Horizon Persona Management to retain user settings and data between sessions even after the desktop has been refreshed or recomposed. Persona Management has the ability to replicate user profiles to a remote profile store (CIFS share) at configurable intervals.

You can also use a standalone version of Persona Management on physical computers and virtual machines that are not managed by Horizon 7.

Horizon 7 offers the following security features, among others:

- Use two-factor authentication, such as RSA SecurID or RADIUS (Remote Authentication Dial-In User Service), or smart cards to log in.
- Use pre-created Active Directory accounts when provisioning remote desktops and applications in environments that have read-only access policies for Active Directory.
- Use SSL/TLS tunneling to ensure that all connections are completely encrypted.
- Use VMware High Availability to ensure automatic failover.

Scalability features depend on the VMware virtualization platform to manage both desktops and servers:

- Integrate with VMware vSphere to achieve cost-effective densities, high levels of availability, and advanced resource allocation control for your remote desktops and applications.
- Use the Horizon 7 storage accelerator feature to support end-user logins at larger scales with the same storage resources. This storage accelerator uses features in the vSphere 5 platform to create a host memory cache of common block reads.
- Configure Horizon Connection Server to broker connections between end users and the remote desktops and applications that they are authorized to access.
- Use View Composer to quickly create desktop images that share virtual disks with a master image. Using linked clones in this way conserves disk space and simplifies the management of patches and updates to the operating system.
- Use the Instant Clone feature, introduced in Horizon 7, to quickly create desktop images that share virtual disks and memory with a parent image. Instant Clones not only have the space efficiency of View Composer linked clones, they also eliminate the need to refresh, recompose, rebalance, thus further simplifying management of patches and updates to the operating system. Instant clones eliminate the desktop maintenance window altogether.

The following features provide centralized administration and management:

- Use Microsoft Active Directory to manage access to remote desktops and applications and to manage policies.
- Use Persona Management to simplify and streamline migration from physical to virtual desktops.
- Use the Web-based administrative console to manage remote desktops and applications from any location.
- Use Horizon Administrator to distribute and manage applications packaged with VMware ThinApp™.
- Use a template, or master image, to quickly create and provision pools of desktops.

- Send updates and patches to virtual desktops without affecting user settings, data, or preferences.
- Integrate with VMware Identity Manager so that end users can access remote desktops through the user portal on the Web, as well as use VMware Identity Manager from a browser inside a remote desktop.
- Integrate with Mirage™ and Horizon FLEX™ to manage locally installed virtual machine desktops and to deploy and update applications on dedicated full-clone remote desktops without overwriting user-installed applications.

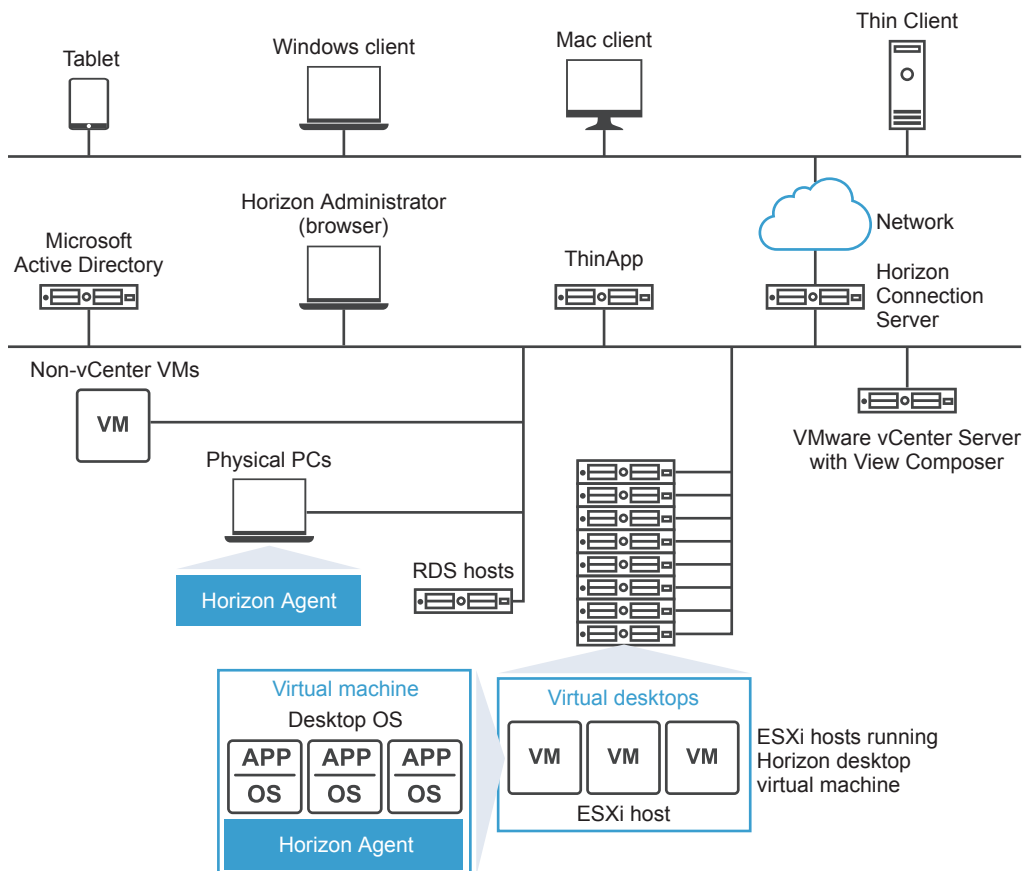
How the Components Fit Together

End users start Horizon Client to log in to Horizon Connection Server. This server, which integrates with Windows Active Directory, provides access to remote desktops hosted on a VMware vSphere server, a physical PC, or a Microsoft RDS host. Horizon Client also provides access to published applications on a Microsoft RDS host.

Note Horizon 7 supports Active Directory Domain Services (AD DS) domain functional levels. For more information about supported AD DS domain functional levels, see the VMware Knowledge Base (KB) article <http://kb.vmware.com/kb/2150351>.

Figure 1-2 shows the relationship between the major components of a Horizon 7 deployment.

Figure 1-2. High-Level Example of a Horizon 7 Environment



Client Devices

A major advantage of using Horizon 7 is that remote desktops and applications follow the end user regardless of device or location. Users can access their personalized virtual desktop or remote application from a company laptop, their home PC, a thin client device, a Mac, or a tablet or phone.

End users open Horizon Client to display their remote desktops and applications. Thin client devices use Horizon 7 thin client software and can be configured so that the only application that users can launch directly on the device is Horizon 7 Thin Client. Repurposing a legacy PC into a thin client desktop can extend the life of the hardware by three to five years. For example, by using Horizon 7 on a thin desktop, you can use a newer operating system such as Windows 8.x on older desktop hardware.

If you use the HTML Access feature, end users can open a remote desktop inside a browser, without having to install any client application on the client system or device.

Horizon Connection Server

This software service acts as a broker for client connections. Horizon Connection Server authenticates users through Windows Active Directory and directs the request to the appropriate virtual machine, physical PC, or Microsoft RDS host.

Connection Server provides the following management capabilities:

- Authenticating users
- Entitling users to specific desktops and pools
- Assigning applications packaged with VMware ThinApp to specific desktops and pools
- Managing remote desktop and application sessions
- Establishing secure connections between users and remote desktops and applications
- Enabling single sign-on
- Setting and applying policies

Inside the corporate firewall, you install and configure a group of two or more Connection Server instances. Their configuration data is stored in an embedded LDAP directory and is replicated among members of the group.

Outside the corporate firewall, in the DMZ, you can install and configure Connection Server as a security server, or you can install a Unified Access Gateway appliance. Security servers and Unified Access Gateway appliances in the DMZ communicate with Connection Servers inside the corporate firewall. Security servers and Unified Access Gateway appliances ensure that the only remote desktop and application traffic that can enter the corporate data center is traffic on behalf of a strongly authenticated user. Users can access only the resources that they are authorized to access.

Security servers offer a subset of functionality and are not required to be in an Active Directory domain. You install Connection Server in a Windows Server 2008 R2 or Windows Server 2012 R2 server, preferably on a VMware virtual machine. For more information about Unified Access Gateway appliances, see *Deploying and Configuring Unified Access Gateway*.

Important It is possible to create a Horizon 7 setup that does not use Connection Server. If you install the Horizon 7 Agent Direct Connect Plugin in a remote virtual machine desktop, the client can connect directly to the virtual machine. All the remote desktop features, including PCoIP, HTML Access, RDP, USB redirection, and session management work in the same way, as if the user had connected through Connection Server. For more information, see *Horizon 7 Agent Direct-Connection Plugin Administration*.

Horizon Client

The client software for accessing remote desktops and applications can run on a tablet, a phone, a Windows, Linux, or Mac PC or laptop, a thin client, and more.

After logging in, users select from a list of remote desktops and applications that they are authorized to use. Authorization can require Active Directory credentials, a UPN, a smart card PIN, or an RSA SecurID or other two-factor authentication token.

An administrator can configure Horizon Client to allow end users to select a display protocol. Protocols include PCoIP, Blast Extreme, and Microsoft RDP for remote desktops. The speed and display quality of PCoIP and Blast Extreme rival that of a physical PC.

Features differ according to which Horizon Client you use. This guide focuses on Horizon Client for Windows. The following types of clients are not described in detail in this guide:

- Details about Horizon Client for tablets, Linux clients, and Mac clients. See the Horizon Client documentation at <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.
- Details about the HTML Access Web client, which allows you to open a remote desktop inside a browser. No Horizon Client application is installed on the client system or device. See the Horizon Client documentation at <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.
- Various third-party thin clients and zero clients, available only through certified partners.
- View Open Client, which supports the VMware partner certification program. View Open Client is not an official client application and is not supported as such.

VMware Horizon User Web Portal

From a Web browser on a client device, end users can connect to remote desktops and applications through the browser, automatically start Horizon Client if it is installed, or download the Horizon Client installer.

When you open a browser and enter the URL of a Horizon Connection Server instance, the Web page that appears contains links to the [VMware Downloads site](#) for downloading Horizon Client. The links on the Web page are configurable, however. For example, you can configure the links to point to an internal Web server, or you can limit which client versions are available on your own Connection Server.

If you use the HTML Access feature, the Web page also displays a link for accessing remote desktops and applications inside a supported browser. With this feature, no Horizon Client application is installed on the client system or device. For more information, see the Horizon Client documentation at <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.

Horizon Agent

You install the Horizon Agent service on all virtual machines, physical systems, and Microsoft RDS hosts that you use as sources for remote desktops and applications. On virtual machines, this agent communicates with Horizon Client to provide features such as connection monitoring, virtual printing, Horizon Persona Management, and access to locally connected USB devices.

If the desktop source is a virtual machine, you first install the Horizon Agent service on that virtual machine and then use the virtual machine as a template or as a parent of linked clones or instant clones. When you create a pool from this virtual machine, the agent is automatically installed on every remote desktop.

You can install the agent with an option for single sign-on. With single sign-on, users are prompted to log in only when they connect to Horizon Connection Server and are not prompted a second time to connect to a remote desktop or application.

Horizon Administrator

This Web-based application allows administrators to configure Horizon Connection Server, deploy and manage remote desktops and applications, control user authentication, and troubleshoot end user issues.

When you install a Connection Server instance, the Horizon Administrator application is also installed. This application allows administrators to manage Connection Server instances from anywhere without having to install an application on their local computer.

View Composer

You can install this software service on a vCenter Server instance that manages virtual machines or on a separate server. View Composer can then create a pool of linked clones from a specified parent virtual machine. This strategy reduces storage costs by up to 90 percent.

Each linked clone acts like an independent desktop, with a unique host name and IP address, yet the linked clone requires significantly less storage because it shares a base image with the parent. Because linked-clone desktop pools share a base image, you can quickly deploy updates and patches by updating only the parent virtual machine. End users' settings, data, and applications are not affected.

You can also use View Composer to create automated farms of linked-clone Microsoft RDS hosts, which provide published applications to end users.

Although you can install View Composer on its own server host, a View Composer service can operate with only one vCenter Server instance. Similarly, a vCenter Server instance can be associated with only one View Composer service.

Important View Composer is an optional component. If you plan to provision instant clones, you do not need to install View Composer.

vCenter Server

This service acts as a central administrator for VMware ESXi servers that are connected on a network. vCenter Server provides the central point for configuring, provisioning, and managing virtual machines in the data center.

In addition to using these virtual machines as sources for virtual machine desktop pools, you can use virtual machines to host the server components of Horizon 7, including Horizon Connection Server instances, Active Directory servers, Microsoft RDS hosts, and vCenter Server instances.

You can install View Composer on the same server as vCenter Server or on a different server. vCenter Server then manages the assignment of the virtual machines to physical servers and storage and manages the assignment of CPU and memory resources to virtual machines.

You can install vCenter Server either as a VMware virtual appliance or install vCenter Server in a Windows Server 2008 R2 server or a Windows Server 2012 R2 server, preferably on a VMware virtual machine.

Integrating and Customizing Horizon 7

To enhance the effectiveness of Horizon 7 in your organization, you can use several interfaces to integrate Horizon 7 with external applications or to create administration scripts that you can run from the command line or in batch mode.

Integrating with Other Components

Horizon 7 integrates with these VMware products.

VMware Cloud on AWS

VMware Cloud on AWS allows you to create vSphere data centers on Amazon Web Services. These vSphere data centers include vCenter Server for managing your data center, vSAN for storage, and VMware NSX for networking. You can connect an on-premise data center to your cloud SDDC, and managed both from a single vSphere Client interface. Using your connected AWS account, you can access AWS services such as EC2 and S3 from virtual machines in your SDDC. For more information, see the VMware Cloud on AWS documentation at <https://docs.vmware.com/en/VMware-Cloud-on-AWS/index.html>.

Starting with Horizon 7 version 7.5, you can deploy Horizon 7 full clones on VMware Cloud on AWS. For example, you can deploy a Horizon 7 environment that uses Cloud Pod Architecture across on-premises data centers and VMware Cloud on AWS instances. This enables Horizon 7 to easily run on a hybrid cloud environment and outsource the management of the SDDC infrastructure to VMware.

VMware Identity Manager

You can integrate VMware Identity Manager with Horizon 7 to provide the following benefits to IT managers and end users:

- End users have on-demand access to remote desktops and applications through the same user portal on the Web that they use to access SaaS, Web, and Windows applications, with the same single sign-on convenience.

With the True SSO feature, users who authenticate using smart cards or two-factor authentication can access their remote desktops and applications without supplying Active Directory credentials.

- End users can access VMware Identity Manager on the Web from inside a remote desktop for applications they need.
- If you also use HTML Access, end users can open a remote desktop inside a browser, without having to install any client application on the client system or device.
- IT managers can use the browser-based administration console of VMware Identity Manager to monitor user and group entitlements to remote desktops.

VMware Mirage and Horizon FLEX

You can use Mirage and Horizon FLEX to deploy and update applications on dedicated full-clone remote desktops without overwriting user-installed applications or data.

Mirage provides a better offline virtual desktop solution than the Local Mode feature that was previously included with Horizon 7. Mirage includes the following security and management features for offline desktops:

- Encrypts the locally installed virtual machine and prevents a user from modifying virtual machine settings that affect the integrity of the secure container.
- Provides policies, including expiration, available in VMware Fusion™ Professional and VMware® Player Plus™, that are comparable to the policies provided with the previous Local Mode feature. Fusion Pro and Player Plus are included with Mirage.
- Eliminates the need for users to check in or check out their desktops to receive updates.

- Enables administrators to utilize the Mirage layering capability, backup features, and file portal.

VMware App Volumes

VMware App Volumes is an integrated and unified application delivery and user management system for Horizon 7 and other virtual environments. Applications and data managed by App Volumes are kept in specialized VMDKs or VHDs called AppStacks, which are attached to each Windows user session at login or reboot. This strategy ensures that the most current applications and data are delivered to the user. App Volumes also provides a different container for persistent user-installed applications and settings called a writable volume, which is also loaded at login or reboot time. User profile and policy settings can also be managed using the App Volumes platform.

VMware User Environment Manager

You can use the Smart Policies feature to create policies that control the behavior of the USB redirection, virtual printing, clipboard redirection, client drive redirection, and PCoIP display protocol features on specific remote desktops. User Environment Manager allows IT to control which settings users are allowed to personalize, and also maps environmental settings such as networks and location-specific printers. With Smart Policies, you can create policies that take effect only if certain conditions are met. For example, you can configure a policy that disables the client drive redirection feature if a user connects to a remote desktop from outside your corporate network.

VMware Unified Access Gateway

Unified Access Gateway functions as a secure gateway for users who want to access remote desktops and applications from outside the corporate firewall. Unified Access Gateway is an appliance that is installed in a demilitarized zone (DMZ). Use Unified Access Gateway to ensure that the only traffic entering the corporate data center is traffic on behalf of a strongly authenticated remote user. You can use Unified Access Gateway appliances instead of Horizon 7 security servers. For more information, see the Unified Access Gateway documentation.

Integrating with Popular Video Conferencing Software

You can use these audio and video conferencing software with Horizon 7.

Flash URL Redirection

Streaming Flash content directly from Adobe Media Server to client endpoints lowers the load on the data center ESXi host, removes the extra routing through the data center, and reduces the bandwidth required to simultaneously stream live video events to multiple client endpoints.

The Flash URL redirection feature uses a JavaScript that is embedded inside a Web page by the Web page administrator. Whenever a virtual desktop user clicks on the designated URL link from within a Web page, the JavaScript intercepts and redirects the ShockWave File (SWF) from the virtual desktop session to the client endpoint. The endpoint then opens a local VMware Flash Projector outside of the virtual desktop session and plays the media stream locally.

Note With Flash URL Redirection, the multicast or unicast stream is redirected to client devices that might be outside your organization's firewall. Your clients must have access to the Adobe Web server that hosts the ShockWave Flash (SWF) file that initiates the multicast or unicast streaming. If needed, configure your firewall to open the appropriate ports to allow client devices to access this server.

This feature is available only on some types of clients. To find out whether this feature is supported on a particular type of client, see the feature support matrix included in the "Using VMware Horizon Client" document for the specific type of desktop or mobile client device. Go to <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.

Microsoft Lync 2013

You can use a Microsoft Lync 2013 client on remote desktops to participate in Unified Communications (UC) VoIP (voice over IP) and video chat calls with Lync certified USB audio and video devices. A dedicated IP phone is no longer required.

This architecture requires the installation of a Microsoft Lync 2013 client on the remote desktop and a Microsoft Lync VDI plug-in on the Windows 7 or 8 client endpoint. Customers can use the Microsoft Lync 2013 client for presence, instant messaging, Web conferencing, and Microsoft Office functionality.

Whenever a Lync VoIP or video chat call occurs, the Lync VDI plug-in offloads all the media processing from the data center server to the client endpoint, and encodes all media into Lync-optimized audio and video codecs. This optimized architecture is highly scalable, results in lower network bandwidth used, and provides point-to-point media delivery with support for high-quality real-time VoIP and video. For more information, see the white paper about VMware Horizon 6 and Microsoft Lync 2013, at <http://www.vmware.com/files/pdf/techpaper/vmware-horizon-view-microsoft-lync-install-configure.pdf>.

Note Recording audio is not yet supported. This integration is supported only with the PCoIP or Blast Extreme display protocol.

Skype for Business

An end user can make optimized audio and video calls with Skype for Business inside a virtual desktop without negatively affecting the virtual infrastructure and overloading the network. All media processing takes place on the client machine instead of in the virtual desktop during a Skype audio and video call.

The Virtualization Pack for Skype for Business software is installed by default as part of the Horizon Client for Windows (4.6 and later), Horizon Client for Linux (4.6 and later), and Horizon Client for Mac (4.7 and later) installers. A Horizon administrator must also install the VMware Virtualization Pack for Skype for Business feature on the virtual desktop during Horizon Agent installation. For more information, see the *Setting Up Virtual Desktops in Horizon 7* document. To configure Skype for Business, see the *Configuring Remote Desktop Features in Horizon 7* document.

Integrating Horizon 7 with Business Intelligence Software

You can configure Horizon Connection Server to record events to a Microsoft SQL Server or Oracle database.

- End-user actions such as logging in and starting a desktop session.
- Administrator actions such as adding entitlements and creating desktop pools.
- Alerts that report system failures and errors.
- Statistical sampling such as recording the maximum number of users over a 24-hour period.

You can use business intelligence reporting engines such as Crystal Reports, IBM Cognos, MicroStrategy 9, and Oracle Enterprise Performance Management System to access and analyze the event database.

For more information, see the *Horizon 7 Integration* document.

You can alternatively generate Horizon 7 events in Syslog format so that the event data can be accessible to analytics software. If you enable file-based logging of events, events are accumulated in a local log file. If you specify a file share, the log files are moved to that share. For more information, see the *Horizon 7 Installation* document.

Using Horizon PowerCLI Cmdlets to Create Administration Scripts

You can use Horizon PowerCLI cmdlets with VMware PowerCLI. Use Horizon PowerCLI cmdlets to perform various administration tasks on Horizon components.

For more information about Horizon PowerCLI cmdlets, read the *VMware PowerCLI Cmdlets Reference*.

For information on the API specifications to create advanced functions and scripts to use with Horizon PowerCLI, see the View API Reference at the [VMware Developer Center](#).

For more information on sample scripts that you can use to create your own Horizon PowerCLI scripts, see the [Horizon PowerCLI community on GitHub](#).

You can use the Horizon PowerCLI cmdlets to perform various administration tasks on Horizon 7 components.

- Create and update desktop pools.
- Configure multiple network labels to greatly expand the number of IP addresses assigned to virtual machines in a pool.
- Add data center resources to a full virtual machine or linked-clone pool.
- Perform rebalance, refresh, or recompose operations on linked-clone desktops.
- Sample the usage of specific desktops or desktop pools over time.
- Query the event database.
- Query the state of services.

Modifying LDAP Configuration Data in Horizon 7

When you use Horizon Administrator to modify the configuration of Horizon 7, the appropriate LDAP data in the repository is updated. Horizon Connection Server stores its configuration information in an LDAP compatible repository. For example, if you add a desktop pool, Connection Server stores information about users, user groups, and entitlements in LDAP.

You can use VMware and Microsoft command-line tools to export and import LDAP configuration data in LDAP Data Interchange Format (LDIF) files from and into Horizon 7. These commands are for advanced administrators who want to use scripts to update configuration data without using Horizon Administrator or Horizon PowerCLI.

You can use LDIF files to perform a number of tasks.

- Transfer configuration data between Connection Server instances.
- Define a large number of Horizon 7 objects, such as desktop pools, and add these to your Connection Server instances without using Horizon Administrator or Horizon PowerCLI.
- Back up a configuration so that you can restore the state of a Connection Server instance.

For more information, see the *Horizon 7 Integration* document.

Using the vdmadmin Command

You can use the `vdmadmin` command line interface to perform a variety of administration tasks on a Connection Server instance. You can use `vdmadmin` to perform administration tasks that are not possible from within the Horizon Administrator user interface or that need to run automatically from scripts.

For more information, see the *Horizon 7 Administration* document.

Planning a Rich User Experience

Horizon 7 provides the familiar, personalized desktop environment that end users expect. For example, on some client systems, end users can access USB and other devices connected to their local computer, send documents to any printer that their local computer can detect, authenticate with smart cards, and use multiple display monitors.

Horizon 7 includes many features that you might want to make available to your end users. Before you decide which features to use, you must understand the limitations and restrictions of each feature.

This chapter includes the following topics:

- [Feature Support Matrix for Horizon Agent](#)
- [Choosing a Display Protocol](#)
- [Using Published Applications](#)
- [Using Horizon Persona Management to Retain User Data and Settings](#)
- [Using USB Devices with Remote Desktops and Applications](#)
- [Using the Real-Time Audio-Video Feature for Webcams and Microphones](#)
- [Using 3D Graphics Applications](#)
- [Streaming Multimedia to a Remote Desktop](#)
- [Printing from a Remote Desktop](#)
- [Using Single Sign-On for Logging In](#)
- [Monitors and Screen Resolution](#)

Feature Support Matrix for Horizon Agent

When planning which display protocol and features to make available to your end users, use the following information to determine which agent (remote desktop and application) operating systems support the feature.

The types and editions of the supported guest operating system depend on the Windows version. For updates to the list of supported Windows 10 operating systems, see the VMware Knowledge Base (KB) article <http://kb.vmware.com/kb/2149393>. For Windows operating systems, other than Windows 10, see the VMware Knowledge Base (KB) article <http://kb.vmware.com/kb/2150295>.

To see a list of specific remote experience features supported on Windows operating systems where Horizon Agent is installed, see the VMware Knowledge Base (KB) article <http://kb.vmware.com/kb/2150305>.

Note For information about which features are supported on the various types of client devices, see the Horizon Client documentation at <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.

In addition, several VMware partners offer thin and zero client devices for Horizon 7 deployments. The features that are available for each thin or zero client device are determined by the vendor and model and the configuration that an enterprise chooses to use. For information about the vendors and models for thin and zero client devices, see the [VMware Compatibility Guide](#), available on the VMware Web site.

Choosing a Display Protocol

A display protocol provides end users with a graphical interface to a remote desktop or application that resides in the data center. Depending on which type of client device you have, you can choose from among Blast Extreme and PCoIP (PC-over-IP), which VMware provides, or Microsoft RDP (Remote Desktop Protocol).

You can set policies to control which protocol is used or to allow end users to choose the protocol when they log in to a desktop.

Note For some types of clients, neither the PCoIP nor the RDP remote display protocol is used. For example, if you use the HTML Access client, available with the HTML Access feature, the Blast Extreme protocol is used, rather than PCoIP or RDP. Similarly, if you use a remote Linux desktop, Blast Extreme is used.

VMware Blast Extreme

Optimized for the mobile cloud, VMware Blast Extreme supports the broadest range of client devices that are H.264 capable. Of the display protocols, VMware Blast offers the lowest CPU consumption for longer battery life on mobile devices. VMware Blast Extreme can compensate for an increase in latency or a reduction in bandwidth and can leverage both TCP and UDP network transports.

The VMware Blast display protocol can be used for published applications and for remote desktops that use virtual machines or shared-session desktops on an RDS host. The RDS host can be a physical machine or a virtual machine. The VMware Blast display protocol does not operate on a single-user physical computer.

VMware Blast Extreme Features

Key features of VMware Blast Extreme include the following:

- Users outside the corporate firewall can use this protocol with the corporate virtual private network (VPN), or users can make secure, encrypted connections to a security server or Access Point appliance in the corporate DMZ.

- Advanced Encryption Standard (AES) 128-bit encryption is supported and is turned on by default. You can, however, change the encryption key cipher to AES-256.
- Connections from all types of client devices.
- Optimization controls for reducing bandwidth usage on the LAN and WAN.
- Performance counters displayed using PerfMon on Windows agents provide an accurate representation of the current state of the system that also updates at a constant rate for the following:
 - Blast session
 - Imaging
 - Audio
 - CDR
 - USB: USB counters displayed using PerfMon on Windows agents are valid if USB traffic is configured to use VMware Virtual Channel (VVC).
 - Skype for Business: counters are for control traffic only.
 - Clipboard
 - RTAV
 - Serial port and scanner redirection features
 - Virtual printing
 - HTML5 MMR
 - Windows Media MMR: Performance counters appear only if you configured this feature to use VMware Virtual Channel (VVC).
- Network continuity during momentary network loss on Windows clients.
- 32-bit color is supported for virtual displays.
- ClearType fonts are supported.
- Audio redirection with dynamic audio quality adjustment for LAN and WAN.
- Real-Time Audio-Video for using webcams and microphones on some client types.
- Copy and paste of text and, on some clients, images between the client operating system and a remote desktop or published application. For other client types, only copy and paste of plain text is supported. You cannot copy and paste system objects such as folders and files between systems.
- Multiple monitors are supported for some client types. On some clients, you can use up to four monitors with a resolution of up to 2560 x 1600 per display or up to three monitors with a resolution of 4K (3840 x 2160) for Windows 7 remote desktops with Aero disabled. Pivot display and autofit are also supported.

When the 3D feature is enabled, up to two monitors are supported with a resolution of up to 1920 x 1200, or one monitor with a resolution of 4K (3840 x 2160).

- USB redirection is supported for some client types.
- MMR redirection is supported for some Windows client operating systems and some remote desktop operating systems (with Horizon Agent installed).
- Connections to physical machines that have no monitors attached are supported with NVIDIA graphics cards. For best performance, use a graphics card that supports H.264 encoding. This is a technical preview feature for Horizon 7 version 7.1.

If you have an add-in discrete GPU and an embedded GPU, the operating system might default to the embedded GPU. To fix this problem, you can disable or remove the device in Device Manager. If the problem persists, you can install the WDDM graphics driver for the embedded GPU, or disable the embedded GPU in the system BIOS. Refer to your system documentation on how to disable the embedded GPU.

Caution Disabling the embedded GPU might cause future loss of access to functionality such as console access to BIOS setup or NT Boot Loader.

For information about which client devices support specific VMware Blast Extreme features, go to <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.

Recommended Guest Operating System Settings

1 GB of RAM or more and a dual CPU is recommended for playing in high-definition, full screen mode, or 720p or higher formatted video. To use Virtual Dedicated Graphics Acceleration for graphics-intensive applications such as CAD applications, 4 GB of RAM is required.

Video Quality Requirements

- | | |
|-----------------------------|--|
| 480p-formatted video | You can play video at 480p or lower at native resolutions when the remote desktop has a single virtual CPU. If you want to play the video in high-definition Flash or in full screen mode, the desktop requires a dual virtual CPU. Even with a dual virtual CPU desktop, as low as 360p-formatted video played in full screen mode can lag behind audio, particularly on Windows clients. |
| 720p-formatted video | You can play video at 720p at native resolutions if the remote desktop has a dual virtual CPU. Performance might be affected if you play videos at 720p in high definition or in full screen mode. |

1080p-formatted video If the remote desktop has a dual virtual CPU, you can play 1080p formatted video, although the media player might need to be adjusted to a smaller window size.

3D rendering You can configure remote desktops to use software- or hardware-accelerated graphics. The software-accelerated graphics feature enables you to run DirectX 9 and OpenGL 2.1 applications without requiring a physical graphics processing unit (GPU). The hardware-accelerated graphics features enable virtual machines to either share the physical GPUs (graphical processing unit) on a vSphere host or dedicate a physical GPU to a single virtual desktop.

For 3D applications, up to two monitors are supported, and the maximum screen resolution is 1920 x 1200. The guest operating system on the remote desktops must be Windows 7 or later.

For more information about 3D features, see [Using 3D Graphics Applications](#).

Hardware Requirements for Client Systems

For information about processor and memory requirements for the specific type of desktop or mobile client device, go to <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.

PCoIP

PCoIP (PC over IP) provides an optimized desktop experience for the delivery of a published application or an entire remote desktop environment, including applications, images, audio, and video content for a wide range of users on the LAN or across the WAN. PCoIP can compensate for an increase in latency or a reduction in bandwidth, to ensure that end users can remain productive regardless of network conditions.

The PCoIP display protocol can be used for published applications and for remote desktops that use virtual machines, physical machines that contain Teradici host cards, or shared session desktops on an RDS host.

PCoIP Features

Key features of PCoIP include the following:

- Users outside the corporate firewall can use this protocol with your company's virtual private network (VPN), or users can make secure, encrypted connections to a security server or Access Point appliance in the corporate DMZ.
- Advanced Encryption Standard (AES) 128-bit encryption is supported and is turned on by default. You can, however, change the encryption key cipher to AES-256.
- Connections from all types of client devices.
- Optimization controls for reducing bandwidth usage on the LAN and WAN.

- 32-bit color is supported for virtual displays.
- ClearType fonts are supported.
- Audio redirection with dynamic audio quality adjustment for LAN and WAN.
- Real-Time Audio-Video for using webcams and microphones on some client types.
- Copy and paste of text and, on some clients, images between the client operating system and a remote desktop or published application. For other client types, only copy and paste of plain text is supported. You cannot copy and paste system objects such as folders and files between systems.
- Multiple monitors are supported for some client types. On some clients, you can use up to 4 monitors with a resolution of up to 2560 x 1600 per display or up to 3 monitors with a resolution of 4K (3840 x 2160) for Windows 7 remote desktops with Aero disabled. Pivot display and autofit are also supported.

When the 3D feature is enabled, up to 2 monitors are supported with a resolution of up to 1920 x 1200, or one monitor with a resolution of 4K (3840 x 2160).

- USB redirection is supported for some client types.
- MMR redirection is supported for some Windows client operating systems and some remote desktop operating systems (with Horizon Agent installed).

For information about which desktop operating systems support specific PCoIP features, see [Feature Support Matrix for Horizon Agent](#).

For information about which client devices support specific PCoIP features, go to <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.

Recommended Guest Operating System Settings

1GB of RAM or more and a dual CPU is recommended for playing in high-definition, full screen mode, or 720p or higher formatted video. To use Virtual Dedicated Graphics Acceleration for graphics-intensive applications such as CAD applications, 4GB of RAM is required.

Video Quality Requirements

480p-formatted video

You can play video at 480p or lower at native resolutions when the remote desktop has a single virtual CPU. If you want to play the video in high-definition Flash or in full screen mode, the desktop requires a dual virtual CPU. Even with a dual virtual CPU desktop, as low as 360p-formatted video played in full screen mode can lag behind audio, particularly on Windows clients.

720p-formatted video

You can play video at 720p at native resolutions if the remote desktop has a dual virtual CPU. Performance might be affected if you play videos at 720p in high definition or in full screen mode.

1080p-formatted video If the remote desktop has a dual virtual CPU, you can play 1080p formatted video, although the media player might need to be adjusted to a smaller window size.

3D rendering You can configure remote desktops to use software- or hardware-accelerated graphics. The software-accelerated graphics feature enables you to run DirectX 9 and OpenGL 2.1 applications without requiring a physical graphics processing unit (GPU). The hardware-accelerated graphics features enable virtual machines to either share the physical GPUs (graphical processing unit) on a vSphere host or dedicate a physical GPU to a single virtual machine desktop.

For 3D applications, up to 2 monitors are supported, and the maximum screen resolution is 1920 x 1200. The guest operating system on the remote desktops must be Windows 7 or later.

For more information about 3D features, see [Using 3D Graphics Applications](#).

Hardware Requirements for Client Systems

For information about processor and memory requirements, see the "Using VMware Horizon Client" document for the specific type of desktop or mobile client device. Go to <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.

Microsoft RDP

Remote Desktop Protocol is the same multichannel protocol many people already use to access their work computer from their home computer. Microsoft Remote Desktop Connection (RDC) uses RDP to transmit data.

Microsoft RDP is a supported display protocol for remote desktops that use virtual machines, physical machines, or shared session desktops on an RDS host. (Only the PCoIP display protocol and the VMware Blast display protocol are supported for published applications.) Microsoft RDP provides the following features:

- RDP 7 has true multiple monitor support, for up to 16 monitors.
- You can copy and paste text and system objects such as folders and files between the local system and the remote desktop.
- 32-bit color is supported for virtual displays.
- RDP supports 128-bit encryption.
- Users outside the corporate firewall can use this protocol with your company's virtual private network (VPN), or users can make secure, encrypted connections to a View security server in the corporate DMZ.

To support TLSv1.1 and TLSv1.2 connections to Windows 7 and Windows Server 2008 R2, you must apply Microsoft hotfix KB3080079.

Hardware Requirements for Client Systems

For information about processor and memory requirements, see the "Using VMware Horizon Client" document for the specific type of client system. Go to <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.

Note Mobile client 3.x devices use only the PCoIP display protocol. Mobile client 4.x clients use only the PCoIP display protocol or the VMware Blast display protocol.

Using Published Applications

You can use Horizon Client to securely access published Windows-based applications, in addition to remote desktops.

With this feature, after launching Horizon Client and logging in to a Horizon 7 server, users see all the published applications they are entitled to use, in addition to remote desktops. Selecting an application opens a window for that application on the local client device, and the application looks and behaves as if it were locally installed.

For example, on a Windows client computer, if you minimize the application window, an item for that application remains in the Taskbar and looks identical to the way it would look if it were installed on the local Windows computer. You can also create a shortcut for the application that will appear on your client desktop, just like shortcuts for locally installed applications.

Deploying published applications in this way might be preferable to deploying complete remote desktops under the following conditions:

- If an application is set up with a multi-tiered architecture, where the components work better if they are located geographically near each other, using published applications is a good solution.

For example, when a user must access a database remotely, if large amounts of data must be transmitted over the WAN, performance is usually affected. With published applications, all parts of the application can be located in the same data center as the database, so that traffic is isolated and only the screen updates are sent across the WAN.

- From a mobile device, accessing an individual application is easier than opening a remote Windows desktop and then navigating to the application.

To use this feature, you install applications on a Microsoft RDS host. In this respect, Horizon 7 published applications work similarly to other application remoting solutions. Horizon 7 published applications are delivered using either the Blast Extreme display protocol or the PCoIP display protocol, for an optimized user experience.

Using Horizon Persona Management to Retain User Data and Settings

You can use Horizon Persona Management with remote desktops and with physical computers and virtual machines that are not managed by Horizon 7. Persona Management retains changes that users make to their profiles. User profiles comprise a variety of user-generated information.

- User-specific data and desktop settings, which allow the desktop appearance to be the same regardless of which desktop a user logs in to.
- Application data and settings. For example, these settings allow applications to remember toolbar positions and preferences.
- Windows registry entries configured by user applications.

To facilitate these abilities, Persona Management requires storage on a CIFS share equal or greater than the size of the user's local profile.

Minimizing Logon and Logoff Times

Persona Management minimizes the time it takes to log on to and off of desktops. During logon, by default, Horizon 7 downloads only the files that Windows requires, such as user registry files. Horizon 7 takes recent changes in the profile on the remote desktop and copies them to the remote repository at regular intervals.

With Persona Management, you can avoid making any changes to Active Directory in order to have a managed profile. To configure Persona Management, you specify a central repository, without changing the user's properties in Active Directory. With this central repository, you can manage a user's profile in one environment without affecting the physical machines that users might also log on to.

With Persona Management, if you provision desktops with VMware ThinApp applications, the ThinApp sandbox data can also be stored in the user profile. This data can roam with the user but does not significantly affect logon times. This strategy provides better protection against data loss or corruption.

Configuration Options

You can configure Horizon 7 personas at several levels: a single remote desktop, a desktop pool, an OU, or all remote desktops in your deployment. You can also use a standalone version of Persona Management on physical computers and virtual machines that are not managed by Horizon 7.

By setting group policies (GPOs), you have granular control of the files and folders to include in a persona. You can specify whether to include the local settings folder, which files to load at login time, which files to download in the background after a user logs in, and which files within a user's persona to manage with Windows roaming profiles functionality instead of Persona Management.

As with Windows roaming profiles, you can configure folder redirection. You can redirect the following folders to a network share.

Contacts	My Documents	Save Games
Cookies	My Music	Searches
Desktop	My Pictures	Start Menu
Downloads	My Videos	Startup Items
Favorites	Network Neighborhood	Templates
History	Printer Neighborhood	Temporary Internet Files
Links	Recent Items	

Limitations

Persona Management has the following limitations and restrictions:

- This feature is not supported on instant clone desktop pools.
- You must have a Horizon 7 license that includes the Personal Management component.
- Persona Management requires a CIFS (Common Internet File System) share.
- This feature is not supported for use with persistent disk on Windows 10 linked-clone desktop pools.

Using USB Devices with Remote Desktops and Applications

Administrators can configure the ability to use USB devices, such as thumb flash drives, cameras, VoIP (voice-over-IP) devices, and printers, from a virtual desktop. This feature is called USB redirection. A virtual desktop can accommodate up to 128 USB devices.

You can also redirect certain locally connected USB devices for use in published desktops and applications. For information about the specific types of devices that are supported, see the *Configuring Remote Desktop Features in Horizon 7* document.

When you use this feature in desktop pools that are deployed on single-user machines, most USB devices that are attached to the local client system become available in the remote desktop. You can even connect to and manage an iPad from a remote desktop. For example, you can sync your iPad with iTunes installed in your remote desktop. On some client devices, such as Windows and Mac computers, the USB devices are listed in a menu in Horizon Client. You use the menu to connect and disconnect the devices.

In most cases, you cannot use a USB device in your client system and in your remote desktop at the same time. Only a few types of USB devices can be shared between a remote desktop and the local computer. These devices include smart card readers and human interface devices, such as keyboards and pointing devices.

Administrators can specify the types of USB devices to which end users are allowed to connect. For composite devices that contain multiple types of devices, such as a video input device and a storage device, on some client systems, administrators can split the device so that one device (for example, the video input device) is allowed but the other device (for example, the storage device) is not.

The USB redirection feature is available only on certain types of clients. To find out whether this feature is supported on a particular client, see the feature support matrix included in the Horizon Client installation and setup document for that client.

Using the Real-Time Audio-Video Feature for Webcams and Microphones

With the Real-Time Audio-Video feature, you can use the local client system's webcam or microphone in a remote desktop or published application. Real-Time Audio-Video is compatible with standard conferencing applications and browser-based video applications. It supports standard webcams, audio USB devices, and analog audio input.

End users can run Skype, Webex, Google Hangouts, and other online conferencing applications in their remote desktops. This feature redirects video and audio data to the agent machine with a lower bandwidth than can be achieved by using USB redirection. With Real-Time Audio-Video, webcam images and audio input are encoded on the client system and then sent to the agent machine. On the agent machine, a virtual webcam and virtual microphone can decode and play the stream, which the third-party application can use.

No special configuration is necessary, although administrators can set agent-side group policies and registry keys to configure frame rate and image resolution, or to turn off the feature. By default, the resolution is 320 by 240 pixels at 15 frames per second. If needed, administrators can also use client-side configuration settings to set a preferred webcam or audio device.

Note This feature is available only on some types of clients. To find out whether this feature is supported on a particular type of client, see the feature support matrix included in the installation and setup document for the specific type of desktop or mobile client device.

Using 3D Graphics Applications

The software- and hardware-accelerated graphics features available with the Blast Extreme or PCoIP display protocol enable remote desktop users to run 3D applications ranging from Google Earth to CAD and other graphics-intensive applications.

NVIDIA GRID vGPU (shared GPU hardware acceleration)

Available with vSphere 6.0 and later, this feature allows a physical GPU (graphical processing unit) on an ESXi host to be shared among virtual machines. Use this feature if you require high-end, hardware-accelerated workstation graphics.

AMD Multiuser GPU using vDGA

Available with vSphere 6.0 and later, this feature allows multiple virtual machines to share an AMD GPU by making the GPU appear as multiple PCI passthrough devices. This feature offers flexible hardware-accelerated 3D profiles, ranging from lightweight 3D task workers to high-end workstation graphics power users.

Virtual Dedicated Graphics Acceleration (vDGA)

Available with vSphere 5.5 Update 2 and later, this feature dedicates a single physical GPU on an ESXi host to a single virtual machine. Use this feature if you require high-end, hardware-accelerated workstation graphics.

Note Some Intel vDGA cards require a certain vSphere 6 version. See the VMware Hardware Compatibility List at <http://www.vmware.com/resources/compatibility/search.php>. Also, for Intel vDGA, the Intel integrated GPU is used rather than discrete GPUs, as is the case with other vendors.

Virtual Shared Graphics Acceleration (vSGA)

Available with vSphere 5.5 Update 2 and later, this feature allows multiple virtual machines to share the physical GPUs on ESXi hosts. You can use 3D applications for design, modeling, and multimedia.

Soft 3D

Software-accelerated graphics, available with vSphere 5.5 Update 2 and later and later, allows you to run DirectX 9 and OpenGL 2.1 applications without requiring a physical GPU. Use this feature for less demanding 3D applications such as Windows Aero themes, Microsoft Office 2010, and Google Earth.

NVIDIA GRID vGPU and vDGA are now also supported in published applications running on Microsoft RDS hosts.

Important For more information on the various choices and requirements for 3D rendering, see the [VMware white paper](#) about graphics acceleration, the [NVIDIA GRID vGPU Deployment Guide for VMware Horizon 6.1](#), and [NVIDIA GRID Virtual GPU User Guide](#).

Streaming Multimedia to a Remote Desktop

The Windows Media MMR (multimedia redirection) feature, for Windows 7 and Windows 8/8.1 desktops and clients, enables full-fidelity playback on Windows client computers when multimedia files are streamed to a remote desktop.

With MMR, the multimedia stream is processed, that is, decoded, on the Windows client system. The client system plays the media content, thereby offloading the demand on the ESXi host. Media formats that are supported on Windows Media Player are supported; for example: M4V; MOV; MP4; WMP; MPEG-4 Part 2; WMV 7, 8, and 9; WMA; AVI; ACE; MP3; WAV.

Note You must add the MMR port as an exception to your firewall software. The default port for MMR is 9427.

Printing from a Remote Desktop

The virtual printing feature allows end users on some client systems to use local or network printers from a remote desktop without requiring that additional print drivers be installed in the remote desktop operating system. The location-based printing feature allows you to map remote desktops to the printer that is closest to the endpoint client device.

With virtual printing, after a printer is added on a local client computer, that printer is automatically added to the list of available printers on the remote desktop. No further configuration is required. For each printer available through this feature, you can set preferences for data compression, print quality, double-sided printing, color, and so on. Users who have administrator privileges can still install printer drivers on the remote desktop without creating a conflict with the virtual printing component.

Local printer redirection is designed for the following use cases:

- Printers directly connected to USB or serial ports on the client device
- Specialized printers such as bar code printers and label printers connected to the client
- Network printers on a remote network that are not addressable from the virtual session.

To send print jobs to a USB printer, you can either use the USB redirection feature or use the virtual printing feature.

Location-based printing allows IT organizations to map remote desktops to the printer that is closest to the endpoint client device. For example, as a doctor moves from room to room in a hospital, each time the doctor prints a document, the print job is sent to the nearest printer. Using this feature does require that the correct printer drivers be installed in the remote desktop.

Note These printing features are available only on some types of clients. To find out whether a printing feature is supported on a particular type of client, see the feature support matrix included in the installation and setup guide for the specific type of desktop or mobile client device. Go to <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.

Using Single Sign-On for Logging In

The single-sign-on (SSO) feature allows end users to supply Active Directory login credentials only once.

If you do not use the single-sign-on feature, end users must log in twice. They are first prompted for Active Directory credentials to log in to Horizon Connection Server and then are prompted log in to their remote desktop. If smart cards are also used, end users must sign in three times because users must also log in when the smart card reader prompts them for a PIN.

For remote desktops, this feature includes a credential provider dynamic-link library.

True SSO

With the True SSO feature, users are no longer required to supply Active Directory credentials at all. After users log in to VMware Identity Manager using any non-AD method (for example, RSA SecurID or RADIUS authentication), users are not prompted to also enter Active Directory credentials in order to use a remote desktop or application.

If a user authenticates by using smart cards or Active Directory credentials, the True SSO feature is not necessary, but you can configure True SSO to be used even in this case. Then any AD credentials that the user provides are ignored and True SSO is used.

True SSO works by generating a unique, short-lived certificate for the Windows logon process. You must set up a Certificate Authority, if you do not already have one, and a certificate Enrollment Server in order to generate short-lived certificates on behalf of the user. You install the Enrollment Server by running the Connection Server installer and selecting the Enrollment Server option.

True SSO separates authentication (validating a user's identity) from access (such as to a Windows desktop or application). User credentials are secured by a digital certificate. No passwords are vaulted or transferred within the data center. For more information, see the *Horizon 7 Administration* document.

Monitors and Screen Resolution

You can extend a remote desktop to multiple monitors. If you have a high-resolution monitor, you can see the remote desktop or application in full resolution.

You can select the All Monitors display mode to display a remote desktop on multiple monitors. If you are using All Monitors mode and click the Minimize button, if you then maximize the window, the window goes back to All Monitors mode. Similarly, if you are using Fullscreen mode and minimize the window, when you maximize the window, the window goes back to Fullscreen mode on one monitor.

Using All Monitors in a Multiple-Monitor Setup

Regardless of the display protocol, you can use multiple monitors with a remote desktop. If you have Horizon Client use all monitors, if you maximize an application window, the window expands to the full screen of only the monitor that contains it.

Horizon Client supports the following monitor configurations:

- If you use two monitors, the monitors are not required to be in the same mode. For example, if you are using a laptop connected to an external monitor, the external monitor can be in portrait mode or landscape mode.
- Monitors can be placed side by side, stacked two by two, or vertically stacked only if you are using two monitors and the total height is less than 4096 pixels.
- To use the 3D rendering feature, you must use the VMware Blast display protocol or the PCoIP display protocol. You can use up to two monitors, with a resolution of up to 1920 X 1200. For a resolution of 4 K (3840 X 2160), only one monitor is supported.

- With the VMware Blast display protocol or the PCoIP display protocol, a remote desktop screen resolution of 4K (3840 x 2160) is supported. The number of 4K displays that are supported depends on the hardware version of the desktop virtual machine and the Windows version.

Hardware Version	Windows Version	Number of 4K Displays Supported
10 (ESXi 5.5.x compatible)	7, 8, 8.x, 10	1
11 (ESXi 6.0 compatible)	7 (3D rendering feature disabled and Windows Aero disabled)	3
11	7 (3D rendering feature enabled)	1
11	8, 8.x, 10	1
13	8, 8.x, 10	4

- If you use Microsoft RDP 7, the maximum number of monitors that you can use to display a remote desktop is 16.
- If you use Microsoft RDP display protocol, you must have Microsoft Remote Desktop Connection (RDC) 6.0 or later installed in the remote desktop.

Using One Monitor in a Multiple-Monitor Setup

If you have multiple monitors but want Horizon Client to use only one monitor, you can select to have a remote desktop window open in any mode other than All Monitors. By default, the window is opened on the primary monitor. For more information, see the *VMware Horizon Client for Windows Installation and Setup Guide* document.

Using High-Resolution Mode

On some types of clients, when you use the VMware Blast display protocol or the PCoIP display protocol, Horizon Client also supports very high resolutions for those client systems with high-resolution displays. The option to enable High-Resolution Mode appears only if the client system supports high-resolution displays.

Hardware encoding is enabled by default after you have vGPU configured in the virtual machine. Hardware encoding is enabled for all supported multiple-monitor configurations, except vGPU profiles that use less than 1GB of video memory will use the software decoder due to NVENC memory restrictions. See *NVENC requires at least 1 Gbyte of frame buffer* in <https://docs.nvidia.com/grid/4.3/grid-vgpu-release-notes-vmware-vsphere/index.html>

Managing Desktop and Application Pools from a Central Location

3

You can create pools that include one or hundreds or thousands of remote desktops. As a desktop source, you can use virtual machines, physical machines, and Windows Remote Desktop Services (RDS) hosts. Create one virtual machine as a base image, and Horizon 7 can generate a pool of remote desktops from that image. You can also create pools of applications that give users remote access to applications.

This chapter includes the following topics:

- [Advantages of Desktop Pools](#)
- [Advantages of Application Pools](#)
- [Reducing and Managing Storage Requirements](#)
- [Application Provisioning](#)
- [Using Active Directory GPOs to Manage Users and Desktops](#)

Advantages of Desktop Pools

Horizon 7 offers the ability to create and provision pools of desktops as its basis of centralized management.

You create a remote desktop pool from one of the following sources:

- A physical system such as a physical desktop PC.
- A virtual machine that is hosted on an ESXi host and managed by vCenter Server
- A virtual machine that runs on a virtualization platform other than vCenter Server that supports Horizon Agent.
- A session-based desktop on an RDS host. For more information about creating desktop pools from an RDS host, see the *Setting Up Published Desktops and Applications in Horizon 7* document.

If you use a vSphere virtual machine as a desktop source, you can automate the process of making as many identical virtual desktops as you need. You can set a minimum and maximum number of virtual desktops to be generated for the pool. Setting these parameters ensures that you always have enough remote desktops available for immediate use but not so many that you overuse available resources.

Using pools to manage desktops allows you to apply settings or deploy applications to all remote desktops in a pool. The following examples show some of the settings available:

- Specify which remote display protocol to use as the default for the remote desktop and whether to let end users override the default.
- For View Composer linked-clone virtual machines or full clone virtual machines, specify whether to power off the virtual machine when it is not in use and whether to delete it altogether. Instant clone virtual machines are always powered on.
- For View Composer linked-clone virtual machines, you can specify whether to use a Microsoft Sysprep customization specification or QuickPrep from VMware. Sysprep generates a unique SID and GUID for each virtual machine in the pool. Instant clones require a different customization specification, called ClonePrep, from VMware.

You can also specify how users are assigned desktops in a pool.

Dedicated-assignment pools Each user is assigned a particular remote desktop and returns to the same desktop at each login. Dedicated assignment pools require a one-to-one desktop-to-user relationship. For example, a pool of 100 desktops are needed for a group of 100 users.

Floating-assignment pools Using floating-assignment pools also allows you to create a pool of desktops that can be used by shifts of users. For example, a pool of 100 desktops could be used by 300 users if they worked in shifts of 100 users at a time. The remote desktop is optionally deleted and re-created after each use, offering a highly controlled environment.

Advantages of Application Pools

With application pools, you give users access to applications that run on servers in a data center instead of on their personal computers or devices.

Application pools offer several important benefits:

- **Accessibility**
Users can access applications from anywhere on the network. You can also configure secure network access.
- **Device independence**
With application pools, you can support a range of client devices, such as smart phones, tablets, laptops, thin clients, and personal computers. The client devices can run various operating systems, such as Windows, iOS, Mac OS, or Android.
- **Access control**
You can easily and quickly grant or remove access to applications for one user or a group of users.

- Accelerated deployment

With application pools, deploying applications can be accelerated because you only deploy applications on servers in a data center and each server can support multiple users.

- Manageability

Managing software that is deployed on client computers and devices typically requires significant resources. Management tasks include deployment, configuration, maintenance, support, and upgrades. With application pools, you can simplify software management in an enterprise because the software runs on servers in a data center, which requires fewer installed copies.

- Security and regulatory compliance

With application pools, you can improve security because applications and their associated data are centrally located in a data center. Centralized data can address security concerns and regulatory compliance issues.

- Reduced cost

Depending on software license agreements, hosting applications in a data center can be more cost-effective. Other factors, including accelerated deployment and improved manageability, can also reduce the cost of software in an enterprise.

Reducing and Managing Storage Requirements

Deploying desktops on virtual machines that are managed by vCenter Server provides all the storage efficiencies that were previously available only for virtualized servers. Using instant clones or View Composer linked clones as desktop machines increases the storage savings because all virtual machines in a pool share a virtual disk with a base image.

- [Managing Storage with vSphere](#)

vSphere lets you virtualize disk volumes and file systems so that you can manage and configure storage without having to consider where the data is physically stored.

- [Using VMware vSAN for High-Performance Storage and Policy-Based Management](#)

VMware vSAN is a software-defined storage tier, available with vSphere 5.5 Update 2 or a later release, that virtualizes the local physical storage disks available on a cluster of vSphere hosts. You specify only one datastore when creating an automated desktop pool or an automated farm, and the various components, such as virtual machine files, replicas, user data, and operating system files, are placed on the appropriate solid-state drive (SSD) disks or direct-attached hard disks (HDDs).

- [Using Virtual Volumes for Virtual-Machine-Centric Storage and Policy-Based Management](#)

With Virtual Volumes (VVOs), available with vSphere 6.0 or a later release, an individual virtual machine, not the datastore, becomes a unit of storage management. The storage hardware gains control over virtual disk content, layout, and management.

- **Reducing Storage Requirements with View Composer**

Because View Composer creates desktop images that share virtual disks with a base image, you can reduce the required storage capacity by 50 to 90 percent.

- **Reducing Storage Requirements with Instant Clones**

The instant clones feature leverages vSphere vmFork technology (available with vSphere 6.0 U1 and later) to quiesce a running base image, or parent virtual machine, and rapidly create and customize a pool of virtual desktops.

Managing Storage with vSphere

vSphere lets you virtualize disk volumes and file systems so that you can manage and configure storage without having to consider where the data is physically stored.

Fibre Channel SAN arrays, iSCSI SAN arrays, and NAS arrays are widely used storage technologies supported by vSphere to meet different data center storage needs. The storage arrays are connected to and shared between groups of servers through storage area networks. This arrangement allows aggregation of the storage resources and provides more flexibility in provisioning them to virtual machines.

Compatible vSphere 5.5 Update 2 or Later Features

With vSphere 5.5 Update 2 or a later release, you can use vSAN, which virtualizes the local physical solid-state disks and hard disk drives available on ESXi hosts into a single datastore shared by all hosts in a cluster. vSAN provides high-performance storage with policy-based management, so that you specify only one datastore when creating a desktop pool, and the various components, such as virtual machine files, replicas, user data, and operating system files, are placed on the appropriate solid-state drive (SSD) disks or direct-attached hard disks (HDDs).

vSAN also lets you manage virtual machine storage and performance by using storage policy profiles. If the policy becomes noncompliant because of a host, disk, or network failure, or workload changes, vSAN reconfigures the data of the affected virtual machines and optimizes the use of resources across the cluster. You can deploy a desktop pool on a cluster that contains up to 20 ESXi hosts.

While supporting VMware features that require shared storage, such as HA, vMotion, and DRS, vSAN eliminates the need for an external shared storage and simplifies storage configuration and virtual machine provisioning activities.

Important The vSAN feature available with vSphere 6.0 and later releases contains many performance improvements. With vSphere 6.0 this feature also has broader HCL (hardware compatibility) support. For more information about vSAN in vSphere 6 or later, see the *Administering VMware vSAN* document.

Note vSAN is compatible with the View storage accelerator feature but not with the space-efficient disk format feature, which reclaims disk space by wiping and shrinking disks.

With vSphere 5.5 update 2 or a later release, you can use the following features:

- With the View storage accelerator feature, you can configure ESXi hosts to cache virtual machine disk data.

Using this content-based read cache (CBRC) can reduce IOPS and improve performance during boot storms, when many machines start up and run anti-virus scans at the same time. Instead of reading the entire OS from the storage system over and over, a host can read common data blocks from cache.

- If remote desktops use the space-efficient disk format available with vSphere 5.1 and later, stale or deleted data within a guest operating system is automatically reclaimed with a wipe and shrink process.
- Replica disks must be stored on VMFS5 or later datastores or NFS datastores. If you store replicas on a VMFS version earlier than VMFS5, a cluster can have at most eight hosts. OS disks and persistent disks can be stored on NFS or VMFS datastores.

Compatible vSphere 6.0 or Later Features

With vSphere 6.0 or a later release, you can use Virtual Volumes (VVols). This feature maps virtual disks and their derivatives, clones, snapshots, and replicas, directly to objects, called virtual volumes, on a storage system. This mapping allows vSphere to offload intensive storage operations such as snapshotting, cloning, and replication to the storage system.

Virtual Volumes also lets you manage virtual machine storage and performance by using storage policy profiles in vSphere. These storage policy profiles dictate storage services on a per-virtual-machine basis. This type of granular provisioning increases capacity utilization. You can deploy a desktop pool on a cluster that contains up to 32 ESXi hosts.

Note Virtual Volumes is compatible with the View storage accelerator feature but not with the space-efficient disk format feature, which reclaims disk space by wiping and shrinking disks.

Note Instant clones do not support Virtual Volumes.

Using VMware vSAN for High-Performance Storage and Policy-Based Management

VMware VMware vSAN is a software-defined storage tier, available with vSphere 5.5 Update 2 or a later release, that virtualizes the local physical storage disks available on a cluster of vSphere hosts. You specify only one datastore when creating an automated desktop pool or an automated farm, and the various components, such as virtual machine files, replicas, user data, and operating system files, are placed on the appropriate solid-state drive (SSD) disks or direct-attached hard disks (HDDs).

vSAN implements a policy-based approach to storage management. When you use vSAN, Horizon 7 defines virtual machine storage requirements, such as capacity, performance, and availability, in the form of default storage policy profiles and automatically deploys them for virtual desktops onto vCenter Server. The policies are automatically and individually applied per disk (vSAN objects) and maintained throughout

the life cycle of the virtual desktop. Storage is provisioned and automatically configured according to the assigned policies. You can modify these policies in vCenter. Horizon creates vSAN policies for linked-clone desktop pools, instant-clone desktop pools, full-clone desktop pools, or an automated farm per Horizon cluster.

You can enable encryption for a vSAN cluster to encrypt all data-at-rest in the vSAN datastore. vSAN encryption is available with vSAN version 6.6 or later. For more information about encrypting a vSAN cluster, see the *VMware vSAN* documentation.

Each virtual machine maintains its policy regardless of its physical location in the cluster. If the policy becomes noncompliant because of a host, disk, or network failure, or workload changes, vSAN reconfigures the data of the affected virtual machines and load-balances to meet the policies of each virtual machine.

While supporting VMware features that require shared storage, such as HA, vMotion, and DRS, vSAN eliminates the need for an external shared storage infrastructure and simplifies storage configuration and virtual machine provisioning activities.

Important The vSAN feature available with vSphere 6.0 and later releases contains many performance improvements over the feature that was available with vSphere 5.5 Update 2. With vSphere 6.0 this feature also has broader HCL (hardware compatibility) support. Also, VMware vSAN 6.0 supports an all-flash architecture that uses flash-based devices for both caching and persistent storage.

Requirements and Limitations

The vSAN feature has the following limitations when used in a Horizon 7 deployment:

- This release does not support using the Horizon 7 space-efficient disk format feature, which reclaims disk space by wiping and shrinking disks.
- vSAN does not support the View Composer Array Integration (VCAI) feature because vSAN does not use NAS devices.

Note vSAN is compatible with the View Storage Accelerator feature. vSAN provides a caching layer on SSD disks, and the View Storage Accelerator feature provides a content-based cache that reduces IOPS and improves performance during boot storms.

The vSAN feature has the following requirements:

- vSphere 5.5 Update 2 or a later release.
- Appropriate hardware. For example, VMware recommends a 10GB NIC and at least one SSD and one HDD for each capacity-contributing node. For specifics, see the [VMware Compatibility Guide](#).
- A cluster of at least three ESXi hosts. You need enough ESXi hosts to accommodate your setup even if you use two ESXi hosts with a vSAN stretched cluster. For more information, see the *vSphere Configuration Maximums* document.
- SSD capacity that is at least 10 percent of HDD capacity.

- Enough HDDs to accommodate your setup. Do not exceed more than 75% utilization on a magnetic disk.

For more information about vSAN requirements, see "Working with vSAN" in the *vSphere 5.5 Update 2 Storage* document. For vSphere 6 or later, see the *Administering VMware vSAN* document. For guidance on sizing and designing the key components of Horizon 7 virtual desktop infrastructures for VMware vSAN, see the white paper at

<http://www.vmware.com/files/pdf/products/vsan/VMW-TMD-Virt-SAN-Dsn-Szing-Guid-Horizon-View.pdf>.

Using Virtual Volumes for Virtual-Machine-Centric Storage and Policy-Based Management

With Virtual Volumes (VVol), available with vSphere 6.0 or a later release, an individual virtual machine, not the datastore, becomes a unit of storage management. The storage hardware gains control over virtual disk content, layout, and management.

With Virtual Volumes, abstract storage containers replace traditional storage volumes based on LUNs or NFS shares. Virtual Volumes maps virtual disks and their derivatives, clones, snapshots, and replicas, directly to objects, called virtual volumes, on a storage system. With this mapping, vSphere can offload intensive storage operations such as snapshotting, cloning, and replication to the storage system. The result, for example, is that a cloning operation that previously took an hour might now take a few minutes using Virtual Volumes.

Important One of the key benefits of Virtual Volumes is the ability to use Software Policy-Based Management (SPBM). However, for this release, Horizon 7 does not create the default granular storage policies that vSAN creates. Instead, you can set a global default storage policy in vCenter Server that applies to all Virtual Volume datastores.

Virtual Volumes has the following benefits:

- Virtual Volumes supports offloading a number of operations to storage hardware. These operations include snapshotting, cloning, and Storage DRS.
- With Virtual Volumes, you can use advanced storage services that include replication, encryption, deduplication, and compression on individual virtual disks.
- Virtual Volumes supports such vSphere features as vMotion, Storage vMotion, snapshots, linked clones, Flash Read Cache, and DRS.
- You can use Virtual Volumes with storage arrays that support vSphere APIs for Array Integration (VAAI).

Requirements and Limitations

The Virtual Volumes feature has the following limitations when used in a Horizon 7 deployment:

- This release does not support using the Horizon 7 space-efficient disk format feature, which reclaims disk space by wiping and shrinking disks.
- Virtual Volumes does not support using View Composer Array Integration (VCAI).

- Virtual Volumes datastores are not supported for instant clone desktop pools.

Note Virtual Volumes is compatible with the View Storage Accelerator feature. vSAN provides a caching layer on SSD disks, and the View Storage Accelerator feature provides a content-based cache that reduces IOPS and improves performance during boot storms.

The Virtual Volumes feature has the following requirements:

- vSphere 6.0 or a later release.
- Appropriate hardware. Certain storage vendors are responsible for supplying storage providers that can integrate with vSphere and provide support for Virtual Volumes. Every storage provider must be certified by VMware and properly deployed.
- All virtual disks that you provision on a virtual datastore must be an even multiple of 1 MB.

Virtual Volumes is a vSphere 6.0 feature. For more information about the requirements, functionality, background, and setup requirements, see the topics about Virtual Volumes in the *vSphere Storage* document.

Reducing Storage Requirements with View Composer

Because View Composer creates desktop images that share virtual disks with a base image, you can reduce the required storage capacity by 50 to 90 percent.

View Composer uses a base image, or parent virtual machine, and creates a pool of up to 2,000 linked-clone virtual machines. Each linked clone acts like an independent desktop, with a unique host name and IP address, yet the linked clone requires significantly less storage.

Replica and Linked Clones on the Same Datastore

When you create a linked-clone desktop pool or farm of Microsoft RDS hosts, a full clone is first made from the parent virtual machine. The full clone, or replica, and the clones linked to it can be placed on the same data store, or LUN (logical unit number). If necessary, you can use the rebalance feature to move the replica and linked-clone desktop pools from one LUN to another or to move linked-clone desktop pools to a vSAN datastore or from a vSAN datastore to a LUN.

Replica and Linked Clones on Different Datastores

Alternatively, you can place View Composer replicas and linked clones on separate datastores with different performance characteristics. For example, you can store the replica virtual machines on a solid-state drive (SSD). Solid-state drives have low storage capacity and high read performance, typically supporting tens of thousands of I/Os per second (IOPS). You can store linked clones on traditional, spinning media-backed datastores. These disks provide lower performance, but are less expensive and provide higher storage capacity, which makes them suited for storing the many linked clones in a large pool. Tiered storage configurations can be used to cost-effectively handle intensive I/O scenarios such as simultaneous rebooting of many virtual machines or running scheduled antivirus scans.

For more information, see the best-practices guide called *Storage Considerations for VMware View*.

If you use vSAN datastores or Virtual Volumes datastores, you cannot manually select different datastores for replicas and linked clones. Because the vSAN and Virtual Volumes features automatically place objects on the appropriate type of disk and cache of all I/O operations, there is no need to use replica tiering for vSAN and Virtual Volumes datastores.

Disposable Disks for Paging and Temp Files

When you create a linked-clone pool or farm, you can also optionally configure a separate, disposable virtual disk to store the guest operating system's paging and temp files that are generated during user sessions. When the virtual machine is powered off, the disposable disk is deleted. Using disposable disks can save storage space by slowing the growth of linked clones and reducing the space used by powered off virtual machines.

Persistent Disks for Dedicated Desktops

When you create dedicated-assignment desktop pools, View Composer can also optionally create a separate persistent virtual disk for each virtual desktop. The end user's Windows profile and application data are saved on the persistent disk. When a linked clone is refreshed, recomposed, or rebalanced, the contents of the persistent virtual disk are preserved. VMware recommends that you keep View Composer persistent disks on a separate datastore. You can then back up the whole LUN that holds persistent disks.

Local Datastores for Floating, Stateless Desktops

Linked-clone desktops can be stored on local datastores, which are internal spare disks on ESXi hosts. Local storage offers advantages such as inexpensive hardware, fast virtual-machine provisioning, high-performance power operations, and simple management. However, using local storage limits the vSphere infrastructure configuration options that are available to you. Using local storage is beneficial in certain environments but not appropriate in others.

Note The limitations described in this section do not apply to vSAN datastores, which also use local storage disks but require specific hardware, as described in the preceding section about vSAN.

Using local datastores is most likely to work well if the remote desktops in your environment are stateless. For example, you might use local datastores if you deploy stateless kiosks or classroom and training stations.

If you intend to take advantage of the benefits of local storage, you must carefully consider the following limitations:

- You cannot use VMotion, VMware High Availability (HA), or vSphere Distributed Resource Scheduler (DRS).
- You cannot use the View Composer rebalance operation to load-balance virtual machines across a resource pool.
- You cannot store a View Composer replica and linked clones on separate datastores, and, in fact, VMware recommends storing them on the same volume.

If you manage local disk usage by controlling the number of virtual machines and their disk growth, and if you use floating assignments and perform regular refresh and delete operations, you can successfully deploy linked clones to local datastores.

For more information, see the chapter about creating desktop pools in the *Setting Up Virtual Desktops in Horizon 7* document.

Reducing Storage Requirements with Instant Clones

The instant clones feature leverages vSphere vmFork technology (available with vSphere 6.0 U1 and later) to quiesce a running base image, or parent virtual machine, and rapidly create and customize a pool of virtual desktops.

Not only do instant clones share the virtual disks with the parent virtual machine at the time of creation, instant clones also share the memory of the parent. Each instant clone acts like an independent desktop, with a unique host name and IP address, yet the instant clone requires significantly less storage. Instant clones reduce the required storage capacity by 50 to 90 percent. The overall memory requirement is also reduced at clone creation time. For more information on storage requirements and sizing limits, see the VMware Knowledge Base (KB) article <https://kb.vmware.com/kb/2150348>.

Replica and Instant Clones on the Same Datastore

When you create an instant clone desktop pool, a full clone is first made from the master virtual machine. The full clone, or replica, and the clones linked to it can be placed on the same data store, or LUN (logical unit number).

Replica and Instant Clones on Different Datastores

Alternatively, you can place instant clone replicas and instant clones on separate datastores with different performance characteristics. For example, you can store the replica virtual machines on a solid-state drive (SSD). Solid-state drives have low storage capacity and high read performance, typically supporting tens of thousands of I/Os per second (IOPS).

You can store instant clones on traditional, spinning media-backed datastores. These disks provide lower performance, but are less expensive and provide higher storage capacity, which makes them suited for storing the many instant clones in a large pool. Tiered storage configurations can be used to cost-effectively handle intensive I/O scenarios such as simultaneous running scheduled antivirus scans.

If you use vSAN datastores, you cannot manually select different datastores for replicas and instant clones. Because vSAN automatically places objects on the appropriate type of disk and caches all I/O operations, there is no need to use replica tiering for vSAN data stores. Instant clone pools are supported on vSAN data stores.

Storing Instant Clones on Local Datastores

Instant clone virtual machines can be stored on local datastores, which are internal spare disks on ESXi hosts. Local storage offers advantages such as inexpensive hardware, fast virtual-machine provisioning, high-performance power operations, and simple management. However, using local storage limits the vSphere infrastructure configuration options that are available to you. Using local storage is beneficial in certain Horizon 7 environments but not appropriate in others.

Note The limitations described in this topic do not apply to vSAN datastores, which also use local storage disks but require specific hardware.

Using local datastores is most likely to work well if the Horizon 7 desktops in your environment are stateless. For example, you might use local datastores if you deploy stateless kiosks or classroom and training stations.

Consider using local datastores if your virtual machines have floating assignments, are not dedicated to individual end users, and can be deleted or refreshed at regular intervals such as on user logoff. This approach lets you control the disk usage on each local datastore without having to move or load-balance the virtual machines across datastores.

However, you must consider the restrictions that using local datastores imposes on your Horizon 7 desktop or farm deployment:

- You cannot use VMotion to manage Virtual Volumes.
- You cannot use VMware High Availability.
- You cannot use the vSphere Distributed Resource Scheduler (DRS).

If you are deploying instant clones on a single ESXi host with a local datastore, you must configure a cluster containing that single ESXi host. If you have a cluster of two or more ESXi hosts with local datastores, select the local datastore from each of the hosts in the cluster. Otherwise, instant clone creation fails. This behavior differs from the behavior of local datastores with View Composer linked clones.

- You cannot store a replica and instant clones on separate datastores.
- If you select local spinning-disk drives, performance might not match that of a commercially available storage array. Local spinning-disk drives and a storage array might have similar capacity, but local spinning-disk drives do not have the same throughput as a storage array. Throughput increases as the number of spindles grows. If you select direct attached solid-state disks (SSDs), performance is likely to exceed that of many storage arrays.
- If you intend to take advantage of the benefits of local storage, you must carefully consider the consequences of not having VMotion, High Availability, DRS, and other features available. If you manage local disk usage by controlling the number and disk growth of the virtual machines, if you use floating assignments and perform regular refresh and delete operations, you can successfully deploy instant clones to local datastores.

- Local datastore support for instant clones is available for both virtual desktops and published desktops.

Differences between Instant Clones and View Composer Linked Clones

Since instant clones can be created significantly faster than linked clones, the following features of linked clones are no longer needed when you provision a pool of instant clones:

- Instant-clone pools do not support configuration of a separate, disposable virtual disk for storing the guest operating system's paging and temp files. Each time a user logs out of an instant clone desktop, View automatically deletes the clone and provisions and powers on another instant clone based on the latest OS image available for the pool. Any guest operating systems paging and temp files are automatically deleted during the logoff operation.
- Instant-clone pools do not support the creation of a separate persistent virtual disk for each virtual desktop. Instead, you can store the end user's Windows profile and application data on App Volumes' user writable disks. An end user's user writable disk is attached to an instant clone desktop when the end user logs in. In addition, user writable disks can be used to persist user-installed applications.
- Due to short-lived nature of instant-clone desktops, instant clones do not support the space-efficient disk format (SE sparse), with its wipe and shrink process.
- Instant-clone desktop pools are compatible with Storage vMotion. View Composer linked-clone desktop pools are not compatible with Storage vMotion.

Application Provisioning

With Horizon 7, you have several options regarding application provisioning: You can use traditional application provisioning techniques, you can provide published applications rather than a remote desktop, you can distribute application packages created with VMware ThinApp, you can deploy applications as part of a View Composer or instant clone base image, or you can attach applications using App Volumes.

- [Deploying Individual Applications Using an RDS Host](#)
You might choose to provide end users with published applications rather than remote desktops. Individual published applications might be easier to navigate on a small mobile device.
- [Deploying Applications and System Updates with View Composer](#)
Because linked-clone desktop pools share a base image, you can quickly deploy updates and patches by updating the parent virtual machine.
- [Deploying Applications and System Updates with Instant Clones](#)
Because instant clone desktop pools share a base image, you can quickly deploy updates and patches by updating the parent virtual machine.
- [Managing VMware ThinApp Applications in Horizon Administrator](#)
VMware ThinApp™ lets you package an application into a single file that runs in a virtualized application sandbox. This strategy results in flexible, conflict-free application provisioning.

- [Deploying and Managing Applications Using App Volumes](#)

VMware App Volumes offers an alternative way to manage applications by virtualizing applications above the operating system. By using this strategy, applications, data files, settings, middleware, and configurations act as separate, layered containers.

- [Using Existing Processes or VMware Mirage for Application Provisioning](#)

With Horizon 7, you can continue to use the application provisioning techniques that your company currently uses, and you can use Mirage. Two additional considerations include managing server CPU usage and storage I/O and determining whether users are permitted to install applications.

Deploying Individual Applications Using an RDS Host

You might choose to provide end users with published applications rather than remote desktops. Individual published applications might be easier to navigate on a small mobile device.

End users can access published Windows-based applications by using the same Horizon Client that they previously used for accessing remote desktops, and they use the same Blast Extreme or PCoIP display protocol.

To provide a published application, you install the application on a Microsoft Remote Desktop Session (RDS) host. One or more RDS hosts make up a farm, and from that farm administrators create application pools in a similar manner to creating desktop pools. For farm sizing recommendations see the VMware Knowledge Base (KB) article <http://kb.vmware.com/kb/2150348>.

Using this strategy simplifies adding, removing, and updating applications; adding or removing user entitlements to applications; and providing access from any device or network to centrally or distributed application farms.

Deploying Applications and System Updates with View Composer

Because linked-clone desktop pools share a base image, you can quickly deploy updates and patches by updating the parent virtual machine.

The recompose feature allows you to make changes to the parent virtual machine, take a snapshot of the new state, and push the new version of the image to all, or a subset of, users and desktops. You can use this feature for the following tasks:

- Applying operating system and software patches and upgrades
- Applying service packs
- Adding applications
- Adding virtual devices
- Changing other virtual machine settings, such as available memory

Note Because you can also use View Composer to create farms of linked-clone Microsoft RDS hosts, the recompose feature lets you update the guest operating system and applications on RDS hosts.

You can create a View Composer persistent disk that contains user settings and other user-generated data. This persistent disk is not affected by a recompose operation. When a linked clone is deleted, you can preserve the user data. When an employee leaves the company, another employee can access the departing employee's user data. A user who has multiple desktops can consolidate the user data on a single desktop.

If you want to disallow users from adding or removing software or changing settings, you can use the refresh feature to bring the desktop back to its default values. This feature also reduces the size of linked clones, which tend to grow over time.

Deploying Applications and System Updates with Instant Clones

Because instant clone desktop pools share a base image, you can quickly deploy updates and patches by updating the parent virtual machine.

The push image feature allows you to make changes to the parent virtual machine, take a snapshot of the new state, and push the new version of the image to all users and desktops on a rolling basis. With rolling updates, the downtime associated with pool maintenance can be minimized. When a user logs off an instant clone virtual desktop, Horizon 7 deletes the instant clone and creates a fresh new instant clone from the latest version of the image, and the new clone is ready for the next user to log in.

You can use this feature for the following tasks:

- Applying operating system and software patches and upgrades
- Applying service packs
- Adding applications
- Adding virtual devices
- Changing other virtual machine settings, such as available memory

Managing VMware ThinApp Applications in Horizon Administrator

VMware ThinApp™ lets you package an application into a single file that runs in a virtualized application sandbox. This strategy results in flexible, conflict-free application provisioning.

VMware ThinApp provides application virtualization by decoupling an application from the underlying operating system and its libraries and framework and bundling the application into a single executable file called an application package. You can use Horizon Administrator to distribute VMware ThinApp applications to desktops and pools.

Important If, instead of distributing ThinApps by assigning them to desktops and pools, you would rather assign ThinApps to Active Directory users and groups, you can use VMware Identity Manager.

After you create a virtualized application with VMware ThinApp, you can choose to either stream the application from a shared file server or install the application on the virtual desktops. If you configure the virtualized application for streaming, you must address the following architectural considerations:

- Access for specific user groups to specific application repositories, where the application package is stored
- Storage configuration for the application repository
- Network traffic generated by streaming, which depends largely on the type of application

For streamed applications, users launch the applications by using a desktop shortcut.

If you assign a ThinApp package so that it is installed on a virtual desktop, the architectural considerations are similar to those that you address when you use traditional MSI-based software provisioning. Storage configuration for the application repository is a consideration both for streamed applications and for ThinApp packages installed in remote desktops.

Deploying and Managing Applications Using App Volumes

VMware App Volumes offers an alternative way to manage applications by virtualizing applications above the operating system. By using this strategy, applications, data files, settings, middleware, and configurations act as separate, layered containers.

These containers are called application stacks (AppStacks) when in read-only mode or writable volumes when in read-write mode. Administrators can use the App Volumes Manager to create AppStacks and assign application entitlements, and to deliver provisioned AppStacks to the system or to a user or group. Applications delivered by App Volumes look and feel natively installed, and they follow users across sessions and devices. Administrators can update or replace applications in real time and remove any assigned application, either immediately, while the user is still logged in, or at next login or reboot.

For more information, see the VMware App Volumes documentation, available at <https://docs.vmware.com/en/VMware-App-Volumes/index.html>.

Using Existing Processes or VMware Mirage for Application Provisioning

With Horizon 7, you can continue to use the application provisioning techniques that your company currently uses, and you can use Mirage. Two additional considerations include managing server CPU usage and storage I/O and determining whether users are permitted to install applications.

If you push applications out to large numbers of remote desktops at exactly the same time, you might see significant spikes in CPU usage and storage I/O. These peak workloads can have noticeable effects on desktop performance. As a best practice, schedule application updates to occur during off-peak hours and stagger updates to desktops if possible. You must also verify that your storage solution is designed to support such workloads.

If your company allows users to install applications, you can continue your current policies, but you cannot take advantage of View Composer features such as refreshing and recomposing the desktop. With View Composer, if an application is not virtualized or otherwise included in the user's profile or data settings, that application is discarded whenever a View Composer refresh, recompose, or rebalance operation occurs. In many cases, this ability to tightly control which applications are installed is a benefit. View Composer desktops are easy to support because they are kept close to a known good configuration.

If users have firm requirements for installing their own applications and having those applications persist for the lifetime of the remote desktop, instead of using View Composer for application provisioning, you can use instant clones together with App Volumes. Another solution is to create full-clone dedicated desktops, allow users to install applications, and then use Mirage to manage and update the desktops without overwriting user-installed applications.

Important Also use Mirage to manage locally installed offline desktops and their applications. For more information, see the [Mirage Documentation page](#).

Using Active Directory GPOs to Manage Users and Desktops

Horizon 7 includes many Group Policy administrative ADMX templates for centralizing the management and configuration of Horizon 7 components and remote desktops.

After you import these templates into Active Directory, you can use them to set policies that apply to the following groups and components:

- All systems regardless of which user logs in
- All users regardless of the system they log in to
- Connection Server configuration
- Horizon Client configuration
- Horizon Agent configuration

After a GPO is applied, properties are stored in the local Windows registry of the specified component.

You can use GPOs to set all the policies that are available from the Horizon Administrator user interface (UI). You can also use GPOs to set policies that are not available from the UI. For a complete list and description of the settings available through ADMX templates, see *Configuring Remote Desktop Features in Horizon 7*.

Using Smart Policies

You can also use Smart Policies to create policies that control the behavior of the USB redirection, virtual printing, clipboard redirection, client drive redirection, and PCoIP display protocol features on specific remote desktops. This feature requires User Environment Manager.

With Smart Policies, you can create policies that take effect only if certain conditions are met. For example, you can configure a policy that disables the client drive redirection feature if a user connects to a remote desktop from outside your corporate network.

In general, Horizon policy settings that you configure for remote desktop features in User Environment Manager override any equivalent registry key and group policy settings.

Architecture Design Elements and Planning Guidelines for Remote Desktop Deployments

4

A typical Horizon 7 architecture design uses a pod strategy. Pod definitions can vary, based on hardware configuration, Horizon 7 and vSphere software versions used, and other environment-specific design factors.

The examples in this document illustrate a scalable design that you can adapt to your enterprise environment and special requirements. This chapter includes key details about requirements for memory, CPU, storage capacity, network components, and hardware to give IT architects and planners a practical understanding of what is involved in deploying a Horizon 7 solution.

Important This chapter does not cover the following topics:

Architecture design for hosted applications	A Horizon 7 pod can support farms of Microsoft RDS hosts, where each farm contains RDS hosts. For more information, see <i>Setting Up Published Desktops and Applications in Horizon 7</i> . If you plan to use virtual machines for RDS hosts, also see RDS Host Virtual Machine Configuration .
Architecture design for Horizon 7 Agent Direct Connect Plugin	With this plugin running on a remote virtual machine desktop, the client can connect directly to the virtual machine. All the remote desktop features, including PCoIP, HTML Access, RDP, USB redirection, and session management work in the same way, as if the user had connected through View Connection Server. For more information, see <i>Horizon 7 Agent Direct-Connection Plugin Administration</i> .

This chapter includes the following topics:

- [Virtual Machine Requirements for Remote Desktops](#)
- [Horizon 7 ESXi Node](#)
- [Desktop Pools for Specific Types of Workers](#)
- [Desktop Virtual Machine Configuration](#)
- [RDS Host Virtual Machine Configuration](#)
- [vCenter Server and View Composer Virtual Machine Configuration](#)
- [Horizon Connection Server Maximums and Virtual Machine Configuration](#)
- [vSphere Clusters](#)
- [Storage and Bandwidth Requirements](#)
- [Horizon 7 Building Blocks](#)

- [Horizon 7 Pods](#)
- [Advantages of Using Multiple vCenter Servers in a Pod](#)

Virtual Machine Requirements for Remote Desktops

When you plan the specifications for remote desktops, the choices that you make regarding RAM, CPU, and disk space have a significant effect on your choices for server and storage hardware and expenditures.

- [Planning Based on Types of Workers](#)

For many configuration elements, including RAM, CPU, and storage sizing, requirements depend largely on the type of worker who uses the virtual desktop and on the applications that must be installed.

- [Estimating Memory Requirements for Virtual Machine Desktops](#)

RAM costs more for servers than it does for PCs. Because the cost of RAM is a high percentage of overall server hardware costs and total storage capacity needed, determining the correct memory allocation is crucial to planning your desktop deployment.

- [Estimating CPU Requirements for Virtual Machine Desktops](#)

When estimating CPU, you must gather information about the average CPU utilization for various types of workers in your enterprise.

- [Choosing the Appropriate System Disk Size](#)

When allocating disk space, provide only enough space for the operating system, applications, and additional content that users might install or generate. Usually this amount is smaller than the size of the disk that is included on a physical PC.

Planning Based on Types of Workers

For many configuration elements, including RAM, CPU, and storage sizing, requirements depend largely on the type of worker who uses the virtual desktop and on the applications that must be installed.

For architecture planning, workers can be categorized into several types.

Task workers

Task workers and administrative workers perform repetitive tasks within a small set of applications, usually at a stationary computer. The applications are usually not as CPU- and memory-intensive as the applications used by knowledge workers. Task workers who work specific shifts might all log in to their virtual desktops at the same time. Task workers include call center analysts, retail employees, warehouse workers, and so on.

Knowledge workers

Knowledge workers' daily tasks include accessing the Internet, using email, and creating complex documents, presentations, and spreadsheets. Knowledge workers include accountants, sales managers, marketing research analysts, and so on.

Power users	Power users include application developers and people who use graphics-intensive applications.
Kiosk users	These users need to share a desktop that is located in a public place. Examples of kiosk users include students using a shared computer in a classroom, nurses at nursing stations, and computers used for job placement and recruiting. These desktops require automatic login. Authentication can be done through certain applications if necessary.

Estimating Memory Requirements for Virtual Machine Desktops

RAM costs more for servers than it does for PCs. Because the cost of RAM is a high percentage of overall server hardware costs and total storage capacity needed, determining the correct memory allocation is crucial to planning your desktop deployment.

If the RAM allocation is too low, storage I/O can be negatively affected because too much Windows paging occurs. If the RAM allocation is too high, storage capacity can be negatively affected because the paging file in the guest operating system and the swap and suspend files for each virtual machine grow too large.

RAM Sizing Impact on Performance

When allocating RAM, avoid choosing an overly conservative setting. Take the following considerations into account:

- Insufficient RAM allocations can cause excessive Windows paging, which can generate I/O that causes significant performance degradations and increases storage I/O load.
- VMware ESXi supports sophisticated memory resource management algorithms such as transparent page sharing and memory ballooning, which can significantly reduce the physical RAM needed to support a given guest RAM allocation. For example, even though 2GB might be allocated to a virtual desktop, only a fraction of that number is consumed in physical RAM.
- Because virtual desktop performance is sensitive to response times, on the ESXi host, set nonzero values for RAM reservation settings. Reserving some RAM guarantees that idle but in-use desktops are never completely swapped out to disk. It can also reduce storage space consumed by ESXi swap files. However, higher reservation settings affect your ability to overcommit memory on an ESXi host and might affect VMotion maintenance operations.

RAM Sizing Impact on Storage

The amount of RAM that you allocate to a virtual machine is directly related to the size of the certain files that the virtual machine uses. To access the files in the following list, use the Windows guest operating system to locate the Windows page and hibernate files, and use the ESXi host's file system to locate the ESXi swap and suspend files.

Windows page file

By default, this file is sized at 150 percent of guest RAM. This file, which is by default located at `C:\pagefile.sys`, causes thin-provisioned storage to grow because it is accessed frequently. On View Composer linked-clone virtual machines, the page file and temporary files can be redirected to a separate virtual disk that is deleted when the virtual machines are powered off. Disposable page-file redirection saves storage, slowing the growth of linked clones and also can improve performance. Although you can adjust the size from within Windows, doing so might have a negative effect on application performance.

For instant clones, any guest operating systems paging and temp files are automatically deleted during the logoff operation and so do not have time to grow very large. Each time a user logs out of an instant clone desktop, Horizon deletes the clone, and provisions and powers on another instant clone based on the latest OS image available for the pool.

Windows hibernate file for laptops

This file can equal 100 percent of guest RAM. You can safely delete this file because it is not needed in Horizon deployments.

ESXi swap file

This file, which has a `.vswp` extension, is created if you reserve less than 100 percent of a virtual machine's RAM. The size of the swap file is equal to the unreserved portion of guest RAM. For example, if 50 percent of guest RAM is reserved and guest RAM is 2GB, the ESXi swap file is 1GB. This file can be stored on the local data store on the ESXi host or cluster.

ESXi suspend file

This file, which has a `.vmss` extension, is created if you set the desktop pool logoff policy so that the virtual desktop is suspended when the end user logs off. The size of this file is equal to the size of guest RAM.

RAM Sizing for Specific Monitor Configurations When Using PCoIP or Blast Extreme

In addition to system memory, a virtual machine also requires a small amount of RAM on the ESXi host for video overhead. This VRAM size requirement depends in on the display resolution and number of monitors configured for end users. [Table 4-1](#) lists the amount of overhead RAM required for various configurations. The amounts of memory listed in the columns are in addition to the amount of memory required for other PCoIP or Blast Extreme functionality.

Table 4-1. PCoIP or Blast Extreme Client Display Overhead

Display Resolution Standard	Width, in Pixels	Height, in Pixels	1-Monitor Overhead	2-Monitor Overhead	3-Monitor Overhead	4-Monitor Overhead
VGA	640	480	1.20MB	3.20MB	4.80MB	5.60MB
WXGA	1280	800	4.00MB	12.50MB	18.75MB	25.00MB
1080p	1920	1080	8.00MB	25.40MB	38.00MB	50.60MB
WQXGA	2560	1600	16.00MB	60.00MB	84.80MB	109.60MB
UHD (4K)	3840	2160	32.00MB	78.00MB	124.00MB	Not supported

For calculating system requirements, the VRAM values are in addition to the base system RAM for the virtual machine. Overhead memory is automatically calculated and configured when you specify the maximum number of monitors and select the display resolution in Horizon Administrator.

If you use the 3D rendering feature and select Soft3D or vSGA, you can recalculate using the additional VRAM values in a Horizon Administrator control for configuring VRAM for 3D guests. Alternatively, and for other types of graphics acceleration besides Soft3D and vSGA, you can specify the exact amount of VRAM if you elect to manage VRAM by using vSphere Client.

By default, the multiple-monitor configuration matches the host topology. There is extra overhead precalculated for more than 2 monitors to accommodate additional topology schemes. If you encounter a black screen when starting a remote desktop session, verify that the values for the number of monitors and the display resolution, which are set in Horizon Administrator, match the host system, or manually adjust the amount of memory by using selecting **Manage using vSphere Client** in Horizon Administrator and then set the total video memory value to maximum of 128MB.

RAM Sizing for Specific Workloads and Operating Systems

Because the amount of RAM required can vary widely, depending on the type of worker, many companies conduct a pilot phase to determine the correct setting for various pools of workers in their enterprise.

A good starting point is to allocate 1GB for 32-bit Windows 7 or later desktops and 2GB for 64-bit Windows 7 or later desktops. If you want to use one of the hardware accelerated graphics features for 3D workloads, VMware recommends 2 virtual CPUs and 4GB of RAM. During a pilot, monitor the performance and disk space used with various types of workers and make adjustments until you find the optimal setting for each pool of workers.

Estimating CPU Requirements for Virtual Machine Desktops

When estimating CPU, you must gather information about the average CPU utilization for various types of workers in your enterprise.

CPU requirements vary by worker type. During your pilot phase, use a performance monitoring tool, such as Perfmon in the virtual machine, esxtop in ESXi, or vCenter Server performance monitoring tools, to understand both the average and peak CPU use levels for these groups of workers. Also use the following guidelines:

- Software developers or other power users with high-performance needs might have much higher CPU requirements than knowledge workers and task workers. Dual or Quad virtual CPUs are recommended for 64-bit Windows 7 virtual machines running compute-intensive tasks such as using CAD applications, playing HD videos, or driving 4K display resolutions.
- Single virtual CPUs are generally recommended for other cases.

Because many virtual machines run on one server, CPU can spike if agents such as antivirus agents all check for updates at exactly the same time. Determine which agents and how many agents could cause performance issues and adopt a strategy for addressing these issues. For example, the following strategies might be helpful in your enterprise:

- Use instant clones or View Composer linked clones to update images rather than having software management agents download software updates to each individual virtual desktop.
- Schedule antivirus and software updates to run at nonpeak hours, when few users are likely to be logged in.
- Stagger or randomize when updates occur.
- Use an antivirus product that is compatible with the VMware vShield API. For example, this API has been integrated into VMware vCloud[®] Networking and Security 5.1 and later.

As an informal initial sizing approach, to start, assume that each virtual machine requires 1/8 to 1/10 of a CPU core as the minimum guaranteed compute power. That is, plan a pilot that uses 8 to 10 virtual machines per core. For example, if you assume 8 virtual machines per core and have a 2-socket 8-core ESXi host, you can host 128 virtual machines on the server during the pilot. Monitor the overall CPU usage on the host during this period and ensure that it rarely exceeds a safety margin such as 80 percent to give enough headroom for spikes.

Choosing the Appropriate System Disk Size

When allocating disk space, provide only enough space for the operating system, applications, and additional content that users might install or generate. Usually this amount is smaller than the size of the disk that is included on a physical PC.

Because data center disk space usually costs more per gigabyte than desktop or laptop disk space in a traditional PC deployment, optimize the operating system image size. The following suggestions might help optimize image size:

- Remove unnecessary files. For example, reduce the quotas on temporary Internet files.
- Turn off Windows services such as the indexer service, the defragmenter service, and restore points. For details, see the *Setting Up Virtual Desktops in Horizon 7* document.
- Choose a virtual disk size that is sufficient to allow for future growth, but is not unrealistically large.

- Use centralized file shares or a View Composer persistent disk or App Volumes for user-generated content and user-installed applications.
- If you are using vSphere 5.1 or later, enable space reclamation for vCenter Server and for the linked-clone desktop pools.

If virtual machine desktops use the space-efficient disk format available with vSphere 5.1 or later, stale or deleted data within a guest operating system is automatically reclaimed with a wipe and shrink process.

The amount of storage space required must take into account the following files for each virtual desktop:

- The ESXi suspend file is equivalent to the amount of RAM allocated to the virtual machine.
- By default, the Windows page file is equivalent to 150 percent of RAM.
- Log files can take up as much as 100MB for each virtual machine.
- The virtual disk, or .vmdk file, must accommodate the operating system, applications, and future applications and software updates. The virtual disk must also accommodate local user data and user-installed applications if they are located on the virtual desktop rather than on file shares.

If you use View Composer, the .vmdk files grow over time, but you can control the amount of growth by scheduling View Composer refresh operations, setting a storage over-commit policy for virtual machine desktop pools, and redirecting Windows page and temporary files to a separate, nonpersistent disk.

If you use instant clones, the .vmdk files grow over time within a login session. Whenever a user logs out, the instant clone desktop is automatically deleted and a new instant clone is created and ready for the next user to log in. With this process, the desktop is effectively refreshed and returned to its original size.

You can also add 15 percent to this estimate to be sure that users do not run out of disk space.

Horizon 7 ESXi Node

A node is a single VMware ESXi host that hosts virtual machine desktops in a Horizon 7 deployment.

Horizon 7 is most cost-effective when you maximize the consolidation ratio, which is the number of desktops hosted on an ESXi host. Although many factors affect server selection, if you are optimizing strictly for acquisition price, you must find server configurations that have an appropriate balance of processing power and memory.

There is no substitute for measuring performance under actual, real world scenarios, such as in a pilot, to determine an appropriate consolidation ratio for your environment and hardware configuration.

Consolidation ratios can vary significantly, based on usage patterns and environmental factors. Use the following guidelines:

- As a general framework, consider compute capacity in terms of 8 to 10 virtual desktops per CPU core. For information about calculating CPU requirements for each virtual machine, see [Estimating CPU Requirements for Virtual Machine Desktops](#).

- Think of memory capacity in terms of virtual desktop RAM, host RAM, and overcommit ratio. Although you can have between 8 and 10 virtual desktops per CPU core, if virtual desktops have 1GB or more of RAM, you must also carefully consider physical RAM requirements. For information about calculating the amount of RAM required per virtual machine, see [Estimating Memory Requirements for Virtual Machine Desktops](#).

Note that physical RAM costs are not linear and that in some situations, it can be cost-effective to purchase more smaller servers that do not use expensive DIMM chips. In other cases, rack density, storage connectivity, manageability and other considerations can make minimizing the number of servers in a deployment a better choice.

- In Horizon 7, the View Storage Accelerator feature is turned on by default, which allows ESXi 5.5 Update 2 and later hosts to cache common virtual machine disk data. View Storage Accelerator can improve performance and reduce the need for extra storage I/O bandwidth to manage boot storms and anti-virus scanning I/O storms. This feature requires 1GB of RAM per ESXi host.
- Finally, consider cluster requirements and any failover requirements. For more information, see [Determining Requirements for High Availability](#).

For information about specifications of ESXi hosts in vSphere, see the *VMware vSphere Configuration Maximums* document.

Desktop Pools for Specific Types of Workers

Horizon 7 provides many features to help you conserve storage and reduce the amount of processing power required for various use cases. Many of these features are available as pool settings.

The most fundamental question to consider is whether a certain type of user needs a stateful desktop image or a stateless desktop image. Users who need a stateful desktop image have data in the operating system image itself that must be preserved, maintained, and backed up. For example, these users install some of their own applications or have data that cannot be saved outside of the virtual machine itself, such as on a file server or in an application database.

Stateless desktop images

Also known as nonpersistent desktops, stateless architectures have many advantages, such as being easier to support and having lower storage costs. Other benefits include a limited need to back up the virtual machines and easier, less expensive disaster recovery and business continuity options.

Stateful desktop images

Also known as persistent desktops, these images might require traditional image management techniques. Stateful images can have low storage costs in conjunction with certain storage system technologies. Backup and recovery technologies such as VMware Site Recovery Manager are important when considering strategies for backup, disaster recovery, and business continuity.

There are two ways to create stateless desktop images in Horizon 7:

- You can create floating assignment pools or dedicated assignment pools of instant clone virtual machines. Folder redirection and roaming profiles can optionally be used to store user data.
- You can use View Composer to create floating or dedicated assignment pools of linked clone virtual machines. Folder redirection and roaming profiles can optionally be used to store user data or configure persistent disks to persist user data.

There are several ways to create stateful desktop images in Horizon 7:

- You can create full clones or full virtual machines. Some storage vendors have cost-effective storage solutions for full clones. These vendors often have their own best practices and provisioning utilities. Using one of these vendors might require that you create a manual dedicated-assignment pool.
- You can create pools of instant-clone or linked-clone virtual machines and use App Volumes user writable volumes to attach user data and user-installed apps.

Whether you use stateless or stateful desktops depends on the specific type of worker.

- **Pools for Task Workers**

You can standardize on stateless desktop images for task workers so that the image is always in a well-known, easily supportable configuration and so that workers can log in to any available desktop.

- **Pools for Knowledge Workers and Power Users**

Knowledge workers must be able to create complex documents and have them persist on the desktop. Power users must be able to install their own applications and have them persist. Depending on the nature and amount of personal data that must be retained, the desktop can be stateful or stateless.

- **Pools for Kiosk Users**

Kiosk users might include customers at airline check-in stations, students in classrooms or libraries, medical personnel at medical data entry workstations, or customers at self-service points. Accounts associated with client devices rather than users are entitled to use these desktop pools because users do not need to log in to use the client device or the remote desktop. Users can still be required to provide authentication credentials for some applications.

Pools for Task Workers

You can standardize on stateless desktop images for task workers so that the image is always in a well-known, easily supportable configuration and so that workers can log in to any available desktop.

Because task workers perform repetitive tasks within a small set of applications, you can create stateless desktop images, which help conserve storage space and processing requirements.

Use the following pool settings for instant-clone desktop pools:

- For instant clone pools, to optimize resource utilization, use on demand provisioning to grow or shrink the pool based on usage. Be sure to specify enough spare desktops to satisfy the login rate.

- For instant clone desktop pools, Horizon 7 automatically deletes the instant clone whenever a user logs out. A new instant clone is created and ready for the next user to log in, thus effectively refreshing the desktop on every log out.

Use the following pool settings for View Composer linked-clone desktop pools:

- For View Composer desktop pools, determine what action, if any, to take when users log off. Disks grow over time. You can conserve disk space by refreshing the desktop to its original state when users log off. You can also set a schedule for periodically refreshing desktops. For example, you can schedule desktops to refresh daily, weekly, or monthly.
- If applicable, and if you use View Composer linked-clone pools, consider storing desktops on local ESXi data stores. This strategy can offer advantages such as inexpensive hardware, fast virtual-machine provisioning, high-performance power operations, and simple management. For a list of the limitations, see [Local Datastores for Floating, Stateless Desktops](#). Instant clone pools are not supported on local data stores.

Note For information about other types of storage options, see [Reducing and Managing Storage Requirements](#).

- Use the Persona Management feature so that users always have their preferred desktop appearance and application settings, as with Windows user profiles. If you do not have the desktops set to be refreshed or deleted at logoff, you can configure the persona to be removed at logoff.

Important Persona Management facilitates implementing a floating-assignment pool for those users who want to retain settings between sessions. Previously, one of the limitations of floating-assignment desktops was that when end users logged off, they lost all their configuration settings and any data stored in the remote desktop.

Each time end users logged on, their desktop background was set to the default wallpaper, and they would have to configure each application's preferences again. With Persona Management, an end user of a floating-assignment desktop cannot tell the difference between their session and a session on a dedicated-assignment desktop.

Use the following general pool settings for all desktop pools:

- Create an automated pool so that desktops can be created when the pool is created or can be generated on demand based on pool usage.
- Use floating assignment so that users log in to any available desktop. This setting reduces the number of desktops required if everyone does not need to be logged in at the same time.
- Create instant-clone or View Composer linked-clone desktops so that desktops share the same base image and use less storage space in the data center than full virtual machines.

Pools for Knowledge Workers and Power Users

Knowledge workers must be able to create complex documents and have them persist on the desktop. Power users must be able to install their own applications and have them persist. Depending on the nature and amount of personal data that must be retained, the desktop can be stateful or stateless.

For knowledge workers who do not need user-installed applications except for temporary use, you can create stateless desktop images and save all their personal data outside of the virtual machine, on a file server or in an application database. For other knowledge workers and for power users, you can create stateful desktop images.

Use the following pool settings for instant-clone desktop pools:

- If you use instant clone desktops, implement file share, roaming profile, or another profile management solution.

Use the following pool settings for View Composer linked-clone desktop pools:

- If you use View Composer with vSphere virtual desktops, enable the space reclamation feature for vCenter Server and for the desktop pool. With the space reclamation feature, stale or deleted data within a guest operating system is automatically reclaimed with a wipe and shrink process.
- If you use View Composer linked-clone desktops, implement Persona Management, roaming profiles, or another profile management solution. You can also configure persistent disks so that you can refresh and recompose the linked-clone OS disks while keeping a copy of the user profile on the persistent disks.
- Use the Persona Management feature so that users always have their preferred desktop appearance and application settings, as with Windows user profiles.

Use the following general pool settings for all desktop pools:

- Some power users and knowledge workers, such as accountants, sales managers, marketing research analysts, might need to log into the same desktop every time. Create dedicated assignment pools for them.
- Use vStorage thin provisioning so that at first, each desktop uses only as much storage space as the disk needs for its initial operation.
- For power users and knowledge workers who must install their own applications, which adds data to the operating system disk, there are two options. One option is to create full virtual machine desktops. The other option is to create a pool of linked clones or instant clones, and use App Volumes to persist user-installed applications and user data across logins.
- If knowledge workers do not require user-installed applications except for temporary use, you can create View Composer linked-clone desktops or instant clone desktops. The desktop images share the same base image and use less storage space than full virtual machines.

Pools for Kiosk Users

Kiosk users might include customers at airline check-in stations, students in classrooms or libraries, medical personnel at medical data entry workstations, or customers at self-service points. Accounts associated with client devices rather than users are entitled to use these desktop pools because users do not need to log in to use the client device or the remote desktop. Users can still be required to provide authentication credentials for some applications.

Virtual machine desktops that are set to run in kiosk mode use stateless desktop images because user data does not need to be preserved in the operating system disk. Kiosk mode desktops are used with thin client devices or locked-down PCs. You must ensure that the desktop application implements authentication mechanisms for secure transactions, that the physical network is secure against tampering and snooping, and that all devices connected to the network are trusted.

As a best practice, use dedicated Connection Server instances to handle clients in kiosk mode, and create dedicated organizational units and groups in Active Directory for the accounts of these clients. This practice not only partitions these systems against unwarranted intrusion, but also makes it easier to configure and administer the clients.

To set up kiosk mode, you must use the `vdmadmin` command-line interface and perform several procedures documented in the topics about kiosk mode in the *Horizon 7 Administration* document.

As part of this setup, you can use the following instant-clone desktop pool settings.

- If you are using instant clone desktop pools, Horizon 7 automatically deletes the instant clone whenever a user logs out. A new instant clone is created and ready for the next user to log in, thus effectively refreshing the desktop on every log out.

As part of this setup, you can use the following View Composer linked-clone desktop pool settings.

- If you are using View Composer linked-clone desktops, institute a refresh policy so that the desktop is refreshed frequently, such as at every user logoff.
- If applicable, consider storing desktops on local ESXi datastores. This strategy can offer advantages such as inexpensive hardware, fast virtual-machine provisioning, high-performance power operations, and simple management. For a list of the limitations, see [Local Datastores for Floating, Stateless Desktops](#). Instant clone pools are not supported on local data stores.

Note For information about other types of storage options, see [Reducing and Managing Storage Requirements](#).

As part of this setup, you can use the following general settings for all desktop pools.

- Create an automated pool so that desktops can be created when the pool is created or can be generated on demand based on pool usage.
- Use floating assignment so that users can access any available desktop in the pool.
- Create instant-clone or View Composer linked-clone desktops so that desktops share the same base image and use less storage space in the data center than full virtual machines.
- Use an Active Directory GPO (group policy object) to configure location-based printing, so that the desktop uses the nearest printer. For a complete list and description of the settings available through Group Policy administrative (ADMX) templates, see *Configuring Remote Desktop Features in Horizon 7*.
- Use a GPO or Smart Policies to control whether local USB devices are connected to the desktop when the desktop is launched or when USB devices are plugged in to the client computer.

Desktop Virtual Machine Configuration

The example settings for items such as memory, number of virtual processors, and disk space are specific to Horizon 7.

The amount of system disk space required depends on the number of applications required in the base image. VMware has validated a setup that included 8GB of disk space. Applications included Microsoft Word, Excel, PowerPoint, Adobe Reader, Internet Explorer, McAfee Antivirus, and PKZIP.

The amount of disk space required for user data depends on the role of the end user and organizational policies for data storage. If you use View Composer, this data is kept on a persistent disk.

The guidelines listed in the following table are for a standard Windows 7 or later virtual machine desktop.

Table 4-2. Desktop Virtual Machine Example for Windows 7 or Windows 8

Item	Example
Operating system	32-bit or 64-bit Windows 7 or later (with the latest service pack)
RAM	1GB (4GB if users must have hardware-accelerated graphics for 3D rendering)
Virtual CPU	1 (2 for 64-bit systems or if users must play high-definition or full screen video)
System disk capacity	24GB (slightly less than standard)
User data capacity (as a persistent disk)	5GB (starting point)
Virtual SCSI adapter type	LSI Logic SAS (the default)
Virtual network adapter	VMXNET 3

RDS Host Virtual Machine Configuration

Use RDS (Remote Desktop Services) hosts for providing published applications and session-based remote desktops to end users.

An RDS host can be a physical machine or a virtual machine. This example uses a virtual machine with the specifications listed in the following table. The ESXi host for this virtual machine can be part of a VMware HA cluster to guard against physical server failures.

Table 4-3. RDS Host Virtual Machine Example

Item	Example
Operating system	64-bit Windows Server 2008 R2 or Windows Server 2012 R2
RAM	24GB
Virtual CPU	4
System disk capacity	40GB
Virtual SCSI adapter type	LSI Logic SAS (the default for Windows Server 2008)
Virtual network adapter	VMXNET 3

Table 4-3. RDS Host Virtual Machine Example (Continued)

Item	Example
1 NIC	1 Gigabit
Maximum number of client connections total (including session-based remote desktop connections and published application connections)	50

Note If you configure RDS hosts at the lower end of the resource specifications, you might encounter resource constraints when using all features instead of the default installation.

For more information about RDS host configuration and tested workloads, see the *VMware Horizon 6 Reference Architecture* white paper at <http://www.vmware.com/files/pdf/techpaper/VMware-Reference-Architecture-Horizon-6-View-Mirage-Workspace.pdf>.

vCenter Server and View Composer Virtual Machine Configuration

You can install vCenter Server and View Composer on the same virtual machine or on separate servers. These servers require much more memory and processing power than a desktop virtual machine.

VMware tested having View Composer create and provision 2,000 desktops per pool using vSphere 5.1 or later. VMware also tested having View Composer perform a recompose operation on 2,000 desktops at a time. For these tests, vCenter Server and View Composer were installed on separate virtual machines.

Desktop pool size is limited by the following factors:

- Each desktop pool can contain only one vSphere cluster.
- With some setups, clusters can contain up to 32 hosts. With other setups, clusters are limited to 8 hosts. For more information, see [vSphere Clusters](#).
- Each CPU core has compute capacity for 8 to 10 virtual desktops.
- The number of IP addresses available for the subnet limits the number of desktops in the pool. For example, if your network is set up so that the subnet for the pool contains only 256 usable IP addresses, the pool size is limited to 256 desktops. You can, however, configure multiple network labels to greatly expand the number of IP addresses assigned to virtual machines in a pool.

Although you can install vCenter Server and View Composer on a physical machine, this example uses separate virtual machines with the specifications listed in the following tables. The ESXi host for these virtual machines can be part of a VMware HA cluster to guard against physical server failures.

This example assumes that you are using Horizon 7 with vSphere 5.1 or later and vCenter Server 5.1 or later.

Important This example also assumes that View Composer and vCenter Server are installed on separate virtual machines.

Table 4-4. vCenter Server Virtual Machine Example

Item	Example for a vCenter Server That Manages 10,000 Desktops	Example for a vCenter Server That Manages 2,000 Desktops
Operating system	64-bit Windows Server 2008 R2 Enterprise	64-bit Windows Server 2008 R2 Enterprise
RAM	48GB	10-24GB, depending on vSphere version
Virtual CPU	16	2 -8, depending on vSphere version
System disk capacity	180GB	40GB
Virtual SCSI adapter type	LSI Logic SAS (the default for Windows Server 2008)	LSI Logic SAS (the default for Windows Server 2008)
Virtual network adapter	E1000 (the default)	VMXNET 3 (though E1000, the default, is fine too)
Maximum concurrent vCenter provisioning operations	20	20
Maximum concurrent power operations	50	50

Table 4-5. View Composer Virtual Machine Example

Item	Example for a View Composer That Manages 10,000 Desktops	Example for a View Composer That Manages 2,000 Desktops
Operating system	64-bit Windows Server 2008 R2 Enterprise	64-bit Windows Server 2008 R2 Enterprise
RAM	10GB or more , depending on vSphere version	4-10GB, depending on vSphere version
Virtual CPU	4 or more , depending on vSphere version	2 -4, depending on vSphere version
System disk capacity	50GB	40GB
Virtual SCSI adapter type	LSI Logic SAS (the default for Windows Server 2008)	LSI Logic SAS (the default for Windows Server 2008)
Virtual network adapter	VMXNET 3	VMXNET 3
Maximum View Composer pool size	2,000 desktops	1,000 desktops
Maximum concurrent View Composer maintenance operations	12	12
Maximum concurrent View Composer provisioning operations	8	8

Important VMware recommends that you place the database to which vCenter Server and View Composer connect on a separate virtual machine.

Horizon Connection Server Maximums and Virtual Machine Configuration

When you install Horizon Connection Server, the Horizon Administrator user interface is also installed.

Connection Server Configuration

Although you can install Connection Server on a physical machine, this example uses a virtual machine with the specifications listed in Connection Server Virtual Machine Example. The ESXi host for this virtual machine can be part of a VMware HA cluster to guard against physical server failures.

Table 4-6. Connection Server Virtual Machine Example

Item	Example
Operating system	See supported operating systems in the <i>Horizon 7 Installation</i> document.
RAM	10GB
Virtual CPU	4
System disk capacity	70GB
Virtual SCSI adapter type	LSI Logic SAS (the default for Windows Server 2008)
Virtual network adapter	VMXNET 3
Network adapter	1Gbps NIC

Connection Server Cluster Design Considerations

You can deploy multiple replicated Connection Server instances in a group to support load balancing and high availability. Groups of replicated instances are designed to support clustering within a LAN-connected single-data-center environment.

Important To use a group of replicated Connection Server instances across a WAN, MAN (metropolitan area network), or other non-LAN, in scenarios where a Horizon deployment needs to span data centers, you must use the Cloud Pod Architecture feature. You can link together 25 pods to provide a single large desktop brokering and management environment for five geographically distant sites and provide desktops and applications for up to 50,000 sessions. For more information, see the *Administering Cloud Pod Architecture in Horizon 7* document.

Maximum Connections for Connection Server

Remote Desktop Connections provides information about the tested limits regarding the number of simultaneous connections that a Horizon 7 deployment can accommodate.

Table 4-7. Remote Desktop Connections

Connection Servers per Deployment	Connection Type	Maximum Simultaneous Connections
1 Connection Server	Direct connection, RDP, Blast Extreme, or PCoIP	4,000 (tested configuration)
1 Connection Server	Tunneled connection, RDP	2,000 (default configuration) 4,000 (tested configuration)

Table 4-7. Remote Desktop Connections (Continued)

Connection Servers per Deployment	Connection Type	Maximum Simultaneous Connections
1 Connection Server	PCoIP Secure Gateway connection	2,000 (default configuration) 4,000 (tested configuration)
1 Connection Server	Blast Secure Gateway connection	2,000 (default configuration) 4,000 (tested configuration)
1 Connection Server	Unified Access to physical PCs	2,000 (tested configuration)
1 Connection Server	Unified Access to RDS hosts	2,000 (tested configuration)
7 Connection Servers	Direct connection, RDP, Blast Extreme, or PCoIP	20,000 (tested configuration)

Note Tested configurations are fully supported. To achieve the tested configuration of 4,000 maximum simultaneous connections on a single Connection Server for Tunneled connection, PCoIP Secure Gateway, and Blast Secure Gateway, create the `locked.properties` file on the virtual machine on which Connection Server is installed: `C:\Program Files\VMware\VMware View\Server\sslgateway\conf`. Then, set `maxConnections=4000` in the `locked.properties` file and restart Connection Server. Unified Access Gateway currently supports 2,000 sessions and hence 14 Unified Access Gateway appliances were used while testing 20,000 sessions.

PCoIP Secure Gateway connections are required if you use security servers or Unified Access Gateway appliances for PCoIP connections from outside the corporate network. Blast Secure Gateway connections are required if you use security servers or Unified Access Gateway appliances for Blast Extreme or HTML Access connections from outside the corporate network. Tunneled connections are required if you use security servers or Unified Access Gateway appliances for RDP connections from outside the corporate network and for USB and multimedia redirection (MMR) acceleration with a PCoIP or Blast Secure Gateway connection. You can pair multiple security servers to a single Connection Server instance.

Although a single security server or Unified Access Gateway appliance can support a maximum of 2,000 simultaneous connections, instead of using just one security server per Connection Server instance (with 2,000 sessions), you might choose to use 2 or 4. Monitoring of the security server might indicate that the activity for 2,000 users is too great. The required amount of memory and CPU usage might dictate that you add more security servers per Connection Server instance to spread the load. For example, you might use 2 security servers, with each one handling 1,000 connections, or you might use 4 security servers, with each one handling 500 connections. The ratio of security servers to Connection Server instances depends on the requirements of the particular environment.

The number of connections per Unified Access Gateway appliance is similar to those for security servers. For more information about Unified Access Gateway appliances, see *Deploying and Configuring Unified Access Gateway*.

Note In this example, although 5 Connection Server instances (suitably configured) could handle 20,000 connections, the number 7 is shown in the table for availability planning purposes, and to accommodate connections coming from both inside and outside of the corporate network.

For example, if you had 20,000 users, with 16,000 of them inside the corporate network, you would need 5 Connection Server instances inside the corporate network. That way, if one of the instances became unavailable, the 4 remaining instances could handle the load. Similarly, for the 4,000 connections coming from outside the corporate network, you would use 2 Connection Server instances so that if one became unavailable, you would still have one instance left that could handle the load.

These numbers assume that external connections are presented through a gateway. In this example, each of the Connection Server instances handling external connections would be paired with 3 security servers, so that if one became unavailable, the 2 remaining security servers could handle the load. If using Unified Access Gateway appliances instead of security servers, you would need 3 in total, load balanced across both Connection Server instances, so that if one became unavailable, the 2 remaining appliances could handle the load.

In all cases, users would need to reconnect if they were using a Connection Server or gateway that became unavailable.

Hardware Requirements for Unified Access Gateway with Horizon 7

VMware recommends to use 4 vCPUs and 10GB RAM for Unified Access Gateway appliances to support maximum number of connections when used with Horizon 7.

Table 4-8. Hardware Requirements for Unified Access Gateway

Item	Example
Operating system	OVA (SUSE Linux Enterprise 12 (64-bit))
RAM	4GB
Virtual CPU	4
System disk capacity	20GB (changing the default log level requires additional space)
Virtual SCSI adapter type	LSI Logic Parallel (the default for OVA)
Virtual network adapter	VMXNET 3
Network adapter	1Gbps NIC
Network Mapping	Single NIC option

vSphere Clusters

Horizon 7 deployments can use VMware HA clusters to guard against physical server failures. Depending on your setup, clusters can contain up to 32 nodes.

vSphere and vCenter Server provide a rich set of features for managing clusters of servers that host virtual machine desktops. The cluster configuration is also important because each virtual machine desktop pool must be associated with a vCenter Server resource pool. Therefore, the maximum number of desktops per pool is related to the number of servers and virtual machines that you plan to run per cluster.

In very large Horizon 7 deployments, vCenter Server performance and responsiveness can be improved by having only one cluster object per data center object, which is not the default behavior. By default, vCenter Server creates new clusters within the same data center object.

Under the following conditions, vSphere clusters can contain up to 32 ESXi hosts, or nodes:

- vSphere 5.1 and later, with View Composer linked-clone pools, and store replica disks on NFS datastores or VMFS5 or later datastores
- vSphere 6.0 and later, and store pools on Virtual Volumes datastores

If you have vSphere 5.5 Update 1 and later, and store pools on vSAN datastores, the vSphere clusters can contain up to 20 ESXi hosts.

If you store View Composer replicas on a VMFS version earlier than VMFS5, a cluster can have at most eight hosts. OS disks and persistent disks can be stored on NFS or VMFS datastores.

For more information, see the chapter about creating desktop pools, in the *Setting Up Virtual Desktops in Horizon 7* document. Networking requirements depend on the type of server, the number of network adapters, and the way in which VMotion is configured.

Determining Requirements for High Availability

vSphere, through its efficiency and resource management, lets you achieve industry-leading levels of virtual machines per server. But achieving a higher density of virtual machines per server means that more users are affected if a server fails.

Requirements for high availability can differ substantially based on the purpose of the desktop pool. For example, a stateless desktop image (floating-assignment) pool might have different recovery point objective (RPO) requirements than a stateful desktop image (dedicated-assignment) pool. For a floating-assignment pool, an acceptable solution might be to have users log in to a different desktop if the desktop they are using becomes unavailable.

In cases where availability requirements are high, proper configuration of VMware HA is essential. If you use VMware HA and are planning for a fixed number of desktops per server, run each server at a reduced capacity. If a server fails, the capacity of desktops per server is not exceeded when the desktops are restarted on a different host.

For example, in an 8-host cluster, where each host is capable of running 128 desktops, and the goal is to tolerate a single server failure, make sure that no more than $128 * (8 - 1) = 896$ desktops are running on that cluster. You can also use VMware DRS (Distributed Resource Scheduler) to help balance the desktops among all 8 hosts. You get full use of the extra server capacity without letting any hot-spare resources sit idle. Additionally, DRS can help rebalance the cluster after a failed server is restored to service.

You must also make sure that storage is properly configured to support the I/O load that results from many virtual machines restarting at once in response to a server failure. Storage IOPS has the most effect on how quickly desktops recover from a server failure.

Example: Cluster Configuration Examples

The settings listed in the following tables are Horizon 7-specific. For information about limits of HA clusters in vSphere, see the *VMware vSphere Configuration Maximums* document.

Note The following infrastructure example was tested with View 5.2 and vSphere 5.1. The example uses View Composer linked-clones, rather than instant clones, because the test was performed with View 5.2. The instant clone feature is introduced with Horizon 7. Other features that were not available with View 5.2 include vSAN and Virtual Volumes.

Table 4-9. Horizon 7 Infrastructure Cluster Example

Item	Example
Virtual machines	vCenter Server instances, Active Directory, SQL database server, View Composer, Connection Server instances, security servers, parent virtual machines to use as desktop pool sources
Nodes (ESXi hosts)	6 Dell PowerEdge R720 servers (16 cores * 2 GHz; and 192GB RAM on each host)
SSD storage	Virtual machines for vCenter Server, View Composer, SQL database server, and the parent virtual machines
Non-SSD storage	Virtual machines for Active Directory, Connection Server, and security server
Cluster type	DRS (Distributed Resource Scheduler)/HA

Table 4-10. Virtual Machine Desktop Cluster Example

Item	Example
Number of clusters	5
Number of desktops and pools per cluster	1 pool of 2,000 desktops (virtual machines) per cluster
Nodes (ESXi hosts)	Following are examples of various servers that could be used for each cluster: <ul style="list-style-type: none"> ■ 12 Dell PowerEdge R720 (16 cores * 2 GHz; and 192GB RAM on each host) ■ 16 Dell PowerEdge R710 (12 cores * 2.526 GHz; and 144GB RAM on each host) ■ 8 Dell PowerEdge R810 (24 cores * 2 GHz; and 256GB RAM on each host) ■ 6 Dell PowerEdge R810 + 3 PowerEdge R720
SSD storage	Replica virtual machines

Table 4-10. Virtual Machine Desktop Cluster Example (Continued)

Item	Example
Non-SSD storage	32 Non-SSD datastores for clones (450 GB per datastore)
Cluster type	DRS (Distributed Resource Scheduler)/HA

Storage and Bandwidth Requirements

Several considerations go into planning for shared storage of virtual machine desktops, planning for storage bandwidth requirements with regard to I/O storms, and planning network bandwidth needs.

Details about the storage and networking components used in a test setup at VMware are provided in these related topics.

- [Shared Storage Example](#)

For a View 5.2 test environment, View Composer replica virtual machines were placed on high-read-performance solid-state drives (SSD), which support tens of thousands of I/Os per second (IOPS). Linked clones were placed on traditional, lower-performance spinning media-backed datastores, which are less expensive and provide higher storage capacity. The example uses View Composer linked-clones, rather than instant clones, because the test was performed with View 5.2. The instant clone feature is introduced with Horizon 7.

- [Storage Bandwidth Considerations](#)

In a Horizon 7 environment, logon storms are the main consideration when determining bandwidth requirements.

- [Network Bandwidth Considerations](#)

Certain virtual and physical networking components are required to accommodate a typical workload.

- [View Composer Performance Test Results](#)

These test results describe a View 5.2 setup with 10,000-desktops, in which one vCenter Server 5.1 instance managed 5 pools of 2,000 virtual machine desktops each. Only one maintenance period was required for provisioning a new pool or for recomposing, refreshing, or rebalancing an existing pool of 2,000 virtual machines. A logon storm of 10,000 users was also tested.

- [WAN Support](#)

For wide-area networks (WANs), you must consider bandwidth constraints and latency issues. The PCoIP and Blast Extreme display protocols provided by VMware adapt to varying latency and bandwidth conditions.

Shared Storage Example

For a View 5.2 test environment, View Composer replica virtual machines were placed on high-read-performance solid-state drives (SSD), which support tens of thousands of I/Os per second (IOPS). Linked clones were placed on traditional, lower-performance spinning media-backed datastores, which are less expensive and provide higher storage capacity. The example uses View Composer linked-clones, rather than instant clones, because the test was performed with View 5.2. The instant clone feature is introduced with Horizon 7.

Storage design considerations are one of the most important elements of a successful Horizon 7 architecture. The decision that has the greatest architectural impact is whether to use View Composer desktops, which use linked-clone technology. The ESXi binaries, virtual machine swap files, and View Composer replicas of parent virtual machines are stored on the shared storage system.

The external storage system that vSphere uses can be a Fibre Channel or iSCSI SAN (storage area network), or an NFS (Network File System) NAS (network-attached storage). With the vSAN feature, available with vSphere 5.5 Update 1 or later, the storage system can also be aggregated local server-attached storage.

The following example describes the tiered storage strategy used in a View 5.2 test setup in which one vCenter Server managed 10,000 desktops.

Note This example was used in a View 5.2 setup, which was carried out prior to the release of VMware vSAN. For guidance on sizing and designing the key components of View virtual desktop infrastructures for VMware vSAN, see the white paper at <http://www.vmware.com/files/pdf/products/vsan/VMW-TMD-Virt-SAN-Dsn-Szing-Guid-Horizon-View.pdf>.

The vSAN feature available with vSphere 6.0 and later releases contains many performance improvements over the feature that was available with vSphere 5.5 Update 1. With vSphere 6.0 this feature also has broader HCL (hardware compatibility) support. For more information about vSAN in vSphere 6 or later, see the *Administering VMware vSAN* document.

Physical storage

- EMC VNX7500-block only
- 1.8TB Fast Cache (SSD)
- Eight 10Gbit FCoE front end connections (4 per controller).

SSD storage tier

A single RAID5 storage pool:

- 12 * 200GB EFD
- 250GB LUN for parent images
- 500GB LUN for infrastructure
- 75GB LUNs for replica stores (1 per desktop pool cluster)

Virtual machine desktop storage tier

Two RAID 1/0 storage pools:

For pool 1:

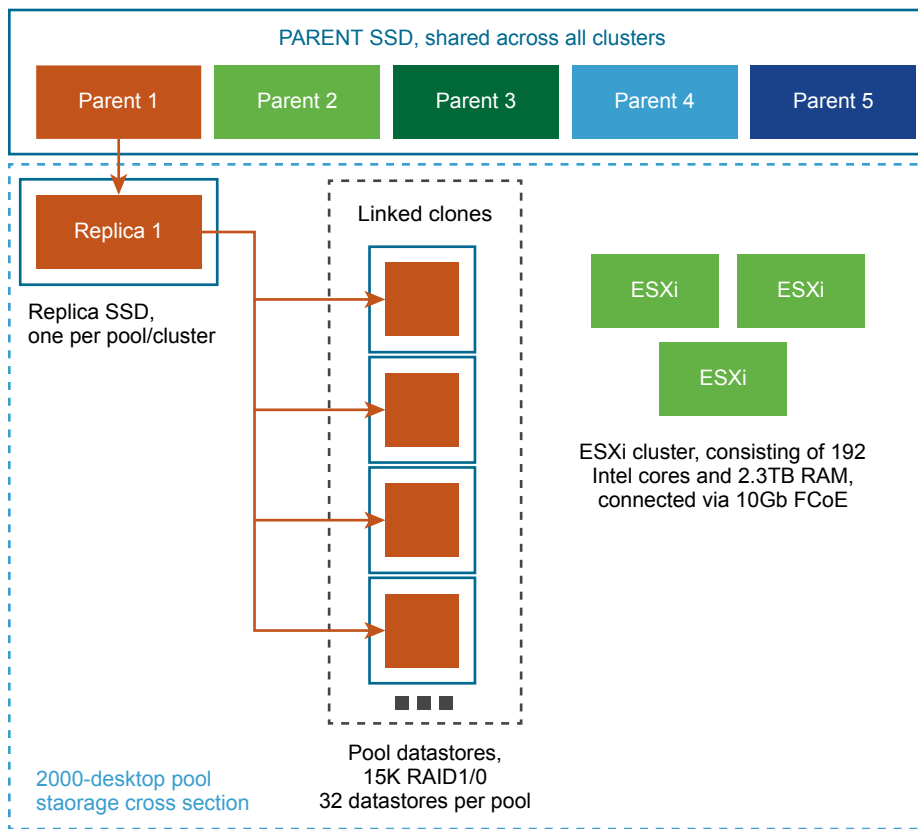
- 360 15K 300GB HDD (47TB usable)
- 97 450GB LUNs for desktops

For pool 2:

- 296 15K 300GB HDD (39TB usable)
- 7 450GB LUNs for infrastructure
- 85 450GB LUNs for desktops

This storage strategy is illustrated in the following figure.

Figure 4-1. Tiered Storage Example for a Large Desktop Pool



From an architectural perspective, View Composer creates desktop images that share a base image, which can reduce storage requirements by 50 percent or more. You can further reduce storage requirements by setting a refresh policy that periodically returns the desktop to its original state and reclaims space that is used to track changes since the last refresh operation.

If you use View Composer with vSphere 5.1 or later virtual machine desktops, you can use the space reclamation feature. With this feature, stale or deleted data within a guest operating system is automatically reclaimed with a wipe and shrink process when the amount of unused disk space reaches a certain threshold. Note that the space reclamation feature is not supported if you use a vSAN datastore.

You can also reduce operating system disk space by using View Composer persistent disks or a shared file server as the primary repository for the user profile and user documents. Because View Composer lets you separate user data from the operating system, you might find that only the persistent disk needs to be backed up or replicated, which further reduces storage requirements. For more information, see [Reducing Storage Requirements with View Composer](#).

Note Decisions regarding dedicated storage components can best be made during a pilot phase. The main consideration is I/Os per second (IOPS). You might experiment with a tiered-storage strategy or vSAN storage to maximize performance and cost savings.

For more information, see the best-practices guide called *Storage Considerations for VMware View*.

Storage Bandwidth Considerations

In a Horizon 7 environment, logon storms are the main consideration when determining bandwidth requirements.

Although many elements are important to designing a storage system that supports a Horizon 7 environment, from a server configuration perspective, planning for proper storage bandwidth is essential. You must also consider the effects of port consolidation hardware.

Horizon 7 environments can occasionally experience I/O storm loads, during which all virtual machines undertake an activity at the same time. I/O storms can be triggered by guest-based agents such as antivirus software or software-update agents. I/O storms can also be triggered by human behavior, such as when all employees log in at nearly the same time in the morning. VMware has tested a logon storm scenario for 10,000 desktops. For more information, see [View Composer Performance Test Results](#).

You can minimize these storm workloads through operational best practices, such as staggering updates to different virtual machines. You can also test various log-off policies during a pilot phase to determine whether suspending or powering off virtual machines when users log off causes an I/O storm. By storing View Composer replicas on separate, high-performance datastores, you can speed up intensive, concurrent read operations to contend with I/O storm loads. For example, you can use one of the following storage strategies:

- Manually configure the pool settings so that replicas are stored on separate, high-performance datastores.
- Use vSAN, available with vSphere 5.5 Update 1 or later, which uses Software Policy-Based Management to determine which kinds of disks to use for replicas.
- Use Virtual Volumes, available with vSphere 6.0 or later, which uses Software Policy-Based Management to determine which kinds of disks to use for replicas.

In addition to determining best practices, VMware recommends that you provide bandwidth of 1Gbps per 100 virtual machines, even though average bandwidth might be 10 times less than that. Such conservative planning guarantees sufficient storage connectivity for peak loads.

Network Bandwidth Considerations

Certain virtual and physical networking components are required to accommodate a typical workload.

For display traffic, many elements can affect network bandwidth, such as protocol used, monitor resolution and configuration, and the amount of multimedia content in the workload. Concurrent launches of streamed applications can also cause usage spikes.

Because the effects of these issues can vary widely, many companies monitor bandwidth consumption as part of a pilot project. As a starting point for a pilot, plan for 150 to 200Kbps of capacity for a typical knowledge worker.

With the PCoIP or Blast Extreme display protocol, if you have an enterprise LAN with 100Mb or a 1Gb switched network, your end users can expect excellent performance under the following conditions:

- Two monitors (1920 x 1080)
- Heavy use of Microsoft Office applications
- Heavy use of Flash-embedded Web browsing
- Frequent use of multimedia with limited use of full screen mode
- Frequent use of USB-based peripherals
- Network-based printing

For more information, see the information guide called *PCoIP Display Protocol: Information and Scenario-Based Network Sizing Guide*.

Optimization Controls Available with PCoIP and Blast Extreme

If you use the PCoIP or the Blast Extreme display protocol from VMware, you can adjust several elements that affect bandwidth usage.

- You can configure the image quality level and frame rate used during periods of network congestion. The quality level setting allows you to limit the initial quality of the changed regions of the display image. You can also adjust the frame rate.

This control works well for static screen content that does not need to be updated or in situations where only a portion needs to be refreshed.

- With regard to session bandwidth, you can configure the maximum bandwidth, in kilobits per second, to correspond to the type of network connection, such as a 4Mbit/s Internet connection. The bandwidth includes all imaging, audio, virtual channel, USB, and PCoIP or Blast control traffic.

You can also configure a lower limit, in kilobits per second, for the bandwidth that is reserved for the session, so that a user does not have to wait for bandwidth to become available. You can specify the Maximum Transmission Unit (MTU) size for UDP packets for a session, from 500 to 1500 bytes.

For more information, see the "PCoIP General Settings" and the "VMware Blast Policy Settings" sections in *Configuring Remote Desktop Features in Horizon 7*.

Network Configuration Example

In a View 5.2 test pod in which one vCenter Server 5.1 instance managed 5 pools of 2,000 virtual machines in each pool, each ESXi host had the following hardware and software for networking requirements.

Note This example was used in a View 5.2 setup, which was carried out prior to the release of VMware vSAN. For guidance on sizing and designing the key components of View virtual desktop infrastructures for VMware vSAN, see the white paper at <http://www.vmware.com/files/pdf/products/vsan/VMW-TMD-Virt-SAN-Dsn-Szing-Guid-Horizon-View.pdf>. Also, the example uses View Composer linked-clones, rather than instant clones, because the test was performed with View 5.2. The instant clone feature is introduced with Horizon 7.

Physical components for each host

- Brocade 1860 Fabric Adapter utilizing 10Gig Ethernet and FCoE for network and storage traffic, respectively.
- Connection to a Brocade VCS Ethernet fabric consisting of 6 VDX6720-60 switches. The switches uplinked to the rest of the network with two 1GB connections to a Juniper J6350 router.

vLAN summary

- One 10Gb vLAN per desktop pool (5 pools)
- One 1Gb vLAN for the management network
- One 1Gb vLAN for the VMotion network
- One 10Gb vLAN for the infrastructure network

Virtual VMotion-dvswitch (1 uplink per host)

This switch was used by the ESXi hosts of infrastructure, parent, and desktop virtual machines.

- Jumbo Frame (9000 MTU)
- 1 Ephemeral Distributed Port Group
- Private VLAN and 192.168.x.x addressing

Infra-dvswitch (2 uplink per host)

This switch was used by the ESXi hosts of infrastructure virtual machines.

- Jumbo frame (9000 MTU)
- 1 Ephemeral distributed port group
- Infrastructure VLAN /24 (256 addresses)

Desktop-dvswitch (2 uplink per host)

This switch was used by the ESXi hosts of parent, and desktop virtual machines.

- Jumbo frame (9000 MTU)
- 6 Ephemeral distributed port groups
- 5 Desktop port groups (1 per pool)

- Each network was /21, 2048 addresses

View Composer Performance Test Results

These test results describe a View 5.2 setup with 10,000-desktops, in which one vCenter Server 5.1 instance managed 5 pools of 2,000 virtual machine desktops each. Only one maintenance period was required for provisioning a new pool or for recomposing, refreshing, or rebalancing an existing pool of 2,000 virtual machines. A logon storm of 10,000 users was also tested.

The test results provided here were accomplished with the software, hardware, and configuration settings described in the following topics:

- Desktop and pool configurations described in [Horizon Connection Server Maximums and Virtual Machine Configuration](#)
- Tiered-storage components described in [Shared Storage Example](#)
- Networking components described in [Network Bandwidth Considerations](#)

Capacity for an Hour-Long Logon Storm of 10,000 Users

Note This example was used in a View 5.2 setup, which was carried out prior to the release of VMware vSAN. For guidance on sizing and designing the key components of View virtual desktop infrastructures for VMware vSAN, see the white paper at <http://www.vmware.com/files/pdf/products/vsan/VMW-TMD-Virt-SAN-Dsn-Szing-Guid-Horizon-View.pdf>. For test results with various workloads and View operations when using vSAN, see the reference architecture white paper at <http://www.vmware.com/files/pdf/techpaper/vmware-horizon-view-virtual-san-reference-architecture.pdf>.

The vSAN feature available with vSphere 6.0 and later releases contains many performance improvements over the feature that was available with vSphere 5.5 Update 1. With vSphere 6.0 this feature also has broader HCL (hardware compatibility) support. For more information about vSAN in vSphere 6 or later, see the *Administering VMware vSAN* document.

In a test setup, the following desktop and pool configurations were used for a logon storm scenario for 10,000 desktops. The power policy for desktops was set to Always On.

For 10,000 desktops the logon storm occurred over a 60-minute period, using a normal distribution of logon times. The virtual machines were powered on and were available before the logon storm began. After logon, a workload started, which included the following applications: Adobe Reader, Microsoft Outlook, Internet Explorer, Microsoft Word, and Notepad.

Following are additional details of the logon storm that was sustained during testing:

- 95% of logons occurred within +/- 2 standard deviation window (40 minutes).
- 68% of logons occurred within +/- 1 standard deviation window (20 minutes).
- Peak logon rate was 400/min, or 6.67/second.

Time Required for Provisioning a Pool

Pools are provisioned either up front, when you create the pool, or on demand, as users are assigned to them. Provisioning means creating the virtual machine and configuring it to use the correct operating system image and network settings.

In a test setup already containing 4 pools of 2,000 virtual machines in each pool, provisioning a fifth pool that contained 2,000 virtual machines took 4 hours. All virtual machines were provisioned up front.

Time Required for Recomposing a Pool

You can use a recompose operation to provide operating system patches, install or update applications, or modify the desktop hardware settings of virtual machines in a pool. Before recomposing a pool, you take a snapshot of a virtual machine that has new configuration. The recompose operation uses that snapshot to update all virtual machines in the pool.

In a test setup of 5 pools of 2,000 virtual machines in each pool, a recompose of one pool of 2,000 virtual machines took 6 hours and 40 minutes. All virtual machines were powered on and available before the recompose operation began.

Time Required for Refreshing a Pool

Because disks grow over time, you can conserve disk space by refreshing a desktop to its original state when users log off, or you can set a schedule for periodically refreshing desktops. For example, you can schedule desktops to refresh daily, weekly, or monthly.

In a test setup of 5 pools of 2,000 virtual machines in each pool, a refresh of one pool of 2,000 virtual machines took 2 hours and 40 minutes. All virtual machines were powered on and available before the refresh operation began.

Time Required for Rebalancing a Pool

A desktop rebalance operation evenly redistributes linked-clone desktops among available logical drives. A rebalance operation saves storage space on overloaded drives and ensures that no drives are underused. You can also use a rebalance operation to migrate all virtual machines in a desktop pool to or from a vSAN datastore.

In a test pod that contained 5 pools of 2,000 virtual machines in each pool, 2 datastores were added to the pod for one test. For another test, 2 datastores were removed from the pod. After the datastores were added or removed, a rebalance operation was performed on one of the pools. A rebalance of one pool of 2,000 virtual machines took 9 hours. All virtual machines were powered on and available before the rebalance operation began.

WAN Support

For wide-area networks (WANs), you must consider bandwidth constraints and latency issues. The PCoIP and Blast Extreme display protocols provided by VMware adapt to varying latency and bandwidth conditions.

If you use the RDP display protocol, you must have a WAN optimization product to accelerate applications for users in branch offices or small offices. With PCoIP and Blast Extreme, many WAN optimization techniques are built into the base protocol.

- WAN optimization is valuable for TCP-based protocols such as RDP because these protocols require many handshakes between client and server. The latency of these handshakes can be quite large. WAN accelerators spoof replies to handshakes so that the latency of the network is hidden from the protocol. Because PCoIP and Blast Extreme are UDP-based, this form of WAN acceleration is unnecessary.
- WAN accelerators also compress network traffic between client and server, but this compression is usually limited to 2:1 compression ratios. PCoIP and Blast Extreme have much higher compression ratios.

For information about the controls that you can use to adjust the way PCoIP and Blast Extreme consume bandwidth, see [Optimization Controls Available with PCoIP and Blast Extreme](#).

Bandwidth Requirements for Various Types of Users

When determining minimum bandwidth requirements for PCoIP, plan with the following estimates:

- 100 to 150Kbps average bandwidth for a basic office productivity desktop: typical office applications with no video, no 3D graphics, and the default Windows and Horizon 7 settings.
- 50 to 100Kbps average bandwidth for an optimized office productivity desktop: typical office applications with no video, no 3D graphics, with Windows desktop settings optimized and Horizon 7 optimized.
- 400 to 600Kbps average bandwidth for virtual desktops utilizing multiple monitors, 3D, Aero, and Microsoft Office.
- 500Kbps to 1Mbps minimum peak bandwidth to provide headroom for bursts of display changes. In general, size your network using the average bandwidth, but consider peak bandwidth to accommodate bursts of imaging traffic associated with large screen changes.
- 2Mbps per simultaneous user running 480p video, depending upon the configured frame rate limit and the video type.

Note The estimate of 50 to 150Kbps per typical user is based on the assumption that all users are operating continuously and performing similar tasks over an 8- to 10- hour day. The 50Kbps bandwidth usage figure is from View Planner testing on a LAN with the Build-to-Lossless feature disabled. Situations may vary in that some users may be fairly inactive and consume almost no bandwidth, allowing more users per link. Therefore, these guidelines are intended to provide a starting point for more detailed bandwidth planning and testing.

The following example shows how to calculate the number of concurrent users at a branch or remote office that has a 1.5Mbps T1 line.

Branch or Remote Office Scenario

- Users have basic Microsoft Office productivity applications, no video, no 3D graphics, and USB keyboards and mouse devices.
- The bandwidth required per typical office user on Horizon 7 is from 50-150Kbps.
- The T1 network capacity is 1.5Mbps.
- Bandwidth utilization is 80 percent (.8 utilization factor).

Formula for Determining the Number of Users Supported

- In the worst case, users require 150Kbps: $(1.5\text{Mbps} \cdot .8) / 150\text{Kbps} = (1500 \cdot .8) / 150 = 8$ users
- In the best case, users require 50Kbps: $(1.5\text{Mbps} \cdot .8) / 50\text{Kbps} = (1500 \cdot .8) / 50 = 24$ users

Result

This remote office can support between 8 and 24 concurrent users per T1 line with 1.5Mbps capacity.

Important You might require optimization of both Horizon 7 and Windows desktop settings to achieve this user density.

Horizon 7 Building Blocks

A building block consists of physical servers, a vSphere infrastructure, Horizon 7 servers, shared storage, and virtual machine desktops for end users. A building block is a logical construct and should not be sized for more than 2,000 Horizon desktops. Customers usually include up to five building blocks in a Horizon 7 pod, although in theory you can use more blocks than that, as long as the pod does not go above 10,000 sessions and 7 Horizon Connection Server instances.

Table 4-11. Example of a LAN-Based Horizon Building Block for 2,000 Virtual Machine Desktops

Item	Example
vSphere clusters	1 or more
80-port network switch	1
Shared storage system	1
vCenter Server with View Composer on the same host	1 (can be run in the block itself)
Database	MS SQL Server or Oracle database server (can be run in the block itself)
VLANs	3 (a 1Gbit Ethernet network for each: management network, storage network, and VMotion network)

Each vCenter Server can support up to 10,000 virtual machines. This support enables you to have building blocks that contain more than 2,000 virtual machine desktops. However, the actual block size is also subject to other Horizon 7-specific limitations.

If you have only one building block in a pod, use two Connection Server instances for redundancy.

Horizon 7 Pods

A pod is a unit of organization determined by Horizon 7 scalability limits.

Pod Example Using Five Building Blocks

A traditional Horizon 7 pod integrates five 2,000-user building blocks that you can manage as one entity.

Table 4-12. Example of a LAN-Based Horizon 7 Pod Constructed of 5 Building Blocks

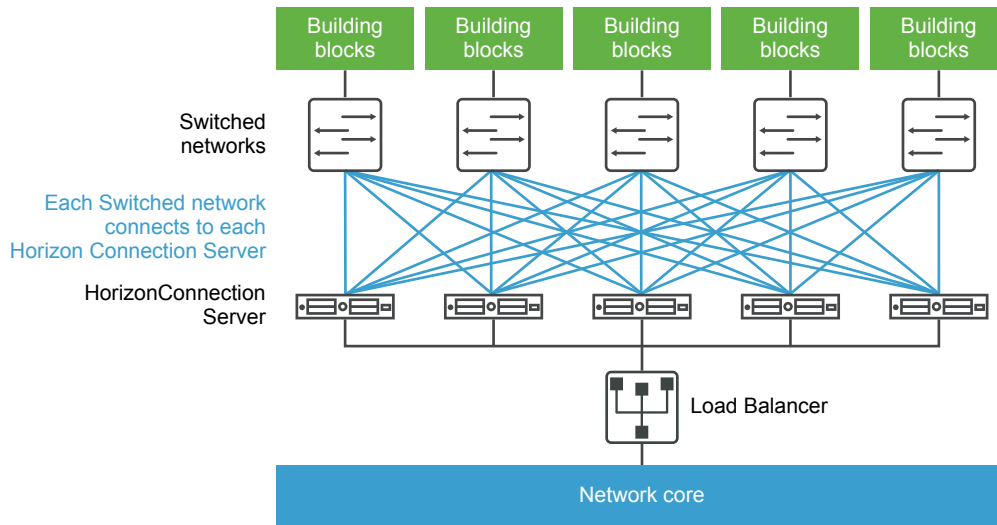
Item	Number
Building blocks for a Horizon 7 pod	5
vCenter Server and View Composer	5 (1 virtual machine that hosts both in each building block)
Database server	5 (1 standalone database server in each building block) MS SQL Server or Oracle database server
Connection Servers	7 (5 for connections from inside the corporate network and 2 for connections from outside)
vLANs	See Table 4-11 .
10Gb Ethernet module	1
Modular networking switch	1

Each vCenter Server can support up to 35,000 registered virtual machines. This support enables you to have building blocks that contain more than 2,000 virtual machine desktops. However, the actual block size is also subject to other Horizon 7-specific limitations.

For both examples described here, a network core can load balance incoming requests across Connection Server instances. Support for a redundancy and failover mechanism, usually at the network level, can prevent the load balancer from becoming a single point of failure. For example, the Virtual Router Redundancy Protocol (VRRP) can communicate with a load balancer to add redundancy and failover capability.

If a Connection Server instance fails or becomes unresponsive during an active session, users do not lose data. Desktop states are preserved in the virtual machine desktop so that users can connect to a different Connection Server instance and their desktop session resumes from where it was when the failure occurred.

Figure 4-2. Pod Diagram for 10,000 Virtual Machine Desktops



Pod Example Using One vCenter Server

In the previous section, the Horizon 7 pod consisted of multiple building blocks. Each building block supported 2,000 virtual machines with a single vCenter Server. VMware has received many requests from both customers and partners to use a single vCenter Server to manage a Horizon 7 pod. This request arises from the fact that a single instance of vCenter Server can support 10,000 virtual machines. Customers have the ability to use a single vCenter Server to manage a 10,000-desktop environment. This topic illustrates an architecture based on using a single vCenter Server to manage 10,000 desktops.

Although using one vCenter Server and one View Composer for 10,000 desktops is possible, doing so creates a situation where there is a single point of failure. The loss of that single vCenter Server renders the entire desktop deployment unavailable for power, provisioning, and refit operations. For this reason, choose a deployment architecture that meets your requirements for overall component resiliency.

For this example, a 10,000-user pod consists of physical servers, a vSphere infrastructure, Horizon 7 servers, shared storage, and 5 clusters of 2,000 virtual desktops per cluster.

Table 4-13. Example of a LAN-Based Horizon 7 Pod with One vCenter Server

Item	Example
vSphere clusters	6 (5 clusters with one linked-clone pool per cluster, and 1 infrastructure cluster)
vCenter Server	1
View Composer	1 (standalone)
Database server	1 (standalone) MS SQL Server or Oracle database server
Active Directory server	1 or 2
Connection Server instances	5

Table 4-13. Example of a LAN-Based Horizon 7 Pod with One vCenter Server (Continued)

Item	Example
Security servers	5
vLANs	8 (5 for the desktop pool clusters, and 1 each for management, VMotion, and the infrastructure cluster)

Cloud Pod Architecture Overview

To use a group of replicated Connection Server instances across a WAN, MAN (metropolitan area network), or other non-LAN, in scenarios where a Horizon deployment needs to span data centers, you must use the Cloud Pod Architecture feature.

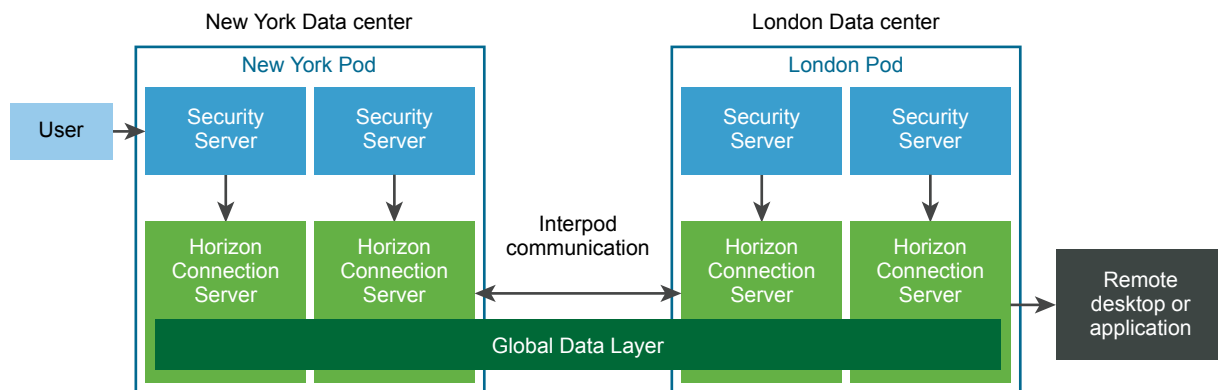
This feature uses standard Horizon components to provide cross-data-center administration, global and flexible user-to-desktop mapping, high-availability desktops, and disaster recovery capabilities.

A typical Cloud Pod Architecture topology consists of two or more pods, which are linked together in a pod federation. Pod federations are subject to certain limits.

Table 4-14. Pod Federation Limits

Object	Limit
Total sessions	200,000
Pods	25
Sessions per pod	10,000
Sites	10
Connection Server instances	175

The following diagram is an example of a basic Cloud Pod Architecture topology.



In the example topology, two previously standalone pods in different data centers are joined together to form a single pod federation. An end user in this environment can connect to a Connection Server instance in the New York data center and receive a desktop or application in the London data center.

The Cloud Pod Architecture feature is not supported in an IPv6 environment.

For more information, see the *Administering Cloud Pod Architecture in Horizon 7* document.

Advantages of Using Multiple vCenter Servers in a Pod

When you create a design for a Horizon 7 production environment that accommodates more than 500 desktops, several considerations affect whether to use one vCenter Server instance rather than multiple instances.

Starting with View 5.2, VMware supports managing up to 10,000 desktop virtual machines within a single Horizon 7 pod with a single vCenter 5.1 or later server. Before you attempt to manage 10,000 virtual machines with a single vCenter Server instance, take the following considerations into account:

- Duration of your company's maintenance windows
- Capacity for tolerating Horizon 7 component failures
- Frequency of power, provisioning, and refit operations
- Simplicity of infrastructure

Duration of Maintenance Windows

Concurrency settings for virtual machine power, provisioning, and maintenance operations are determined per vCenter Server instance.

Pod designs with one vCenter Server instance	<p>Concurrency settings determine how many operations can be queued up for an entire Horizon 7 pod at one time.</p> <p>For example, if you set concurrent provisioning operations to 20 and you have only one vCenter Server instance in a pod, a desktop pool larger than 20 will cause provisioning operations to be serialized. After queuing 20 concurrent operations simultaneously, one operation must complete before the next begins. In large-scale Horizon 7 deployments, this provisioning operation can take a long time.</p>
Pod designs with multiple vCenter Server instances	Each instance can provision 20 virtual machines concurrently.

To ensure more operations are completed simultaneously within one maintenance window, you can add multiple vCenter Server instances (up to five) to your pod, and deploy multiple desktop pools in vSphere clusters managed by separate vCenter Server instances. A vSphere cluster can be managed by only one vCenter Server instance at one time. To achieve concurrency across vCenter Server instances, you must deploy your desktop pools accordingly.

Capacity for Tolerating Component Failures

The role of vCenter Server in Horizon 7 pods is to provide power, provisioning, and refit (refresh, recompose, and rebalance) operations. After a virtual machine desktop is deployed and powered on, Horizon 7 does not rely on vCenter Server for the normal course of operations.

Because each vSphere cluster must be managed by a single vCenter Server instance, this server represents a single point of failure in every Horizon 7 design. This risk is also true for each View Composer instance. (There is a one-to-one mapping between each View Composer instance and vCenter Server instance.) Using one of the following products can mitigate the impact of a vCenter Server or View Composer outage:

- VMware vSphere High Availability (HA)
- VMware vCenter Server Heartbeat™
- Compatible third-party failover products

Important To use one of these failover strategies, the vCenter Server instance must not be installed in a virtual machine that is part of the cluster that the vCenter Server instance manages.

In addition to these automated options for vCenter Server failover, you can also choose to rebuild the failed server on a new virtual machine or physical server. Most key information is stored in the vCenter Server database.

Risk tolerance is an important factor in determining whether to use one or multiple vCenter Server instances in your pod design. If your operations require the ability to perform desktop management tasks such as power and refit of all desktops simultaneously, you should spread the impact of an outage across fewer desktops at a time by deploying multiple vCenter Server instances. If you can tolerate your desktop environment being unavailable for management or provisioning operations for a long period, or if you choose to use a manual rebuild process, you can deploy a single vCenter Server instance for your pod.

Frequency of Power, Provisioning, and Refit Operations

Certain virtual machine desktop power, provisioning, and refit operations are initiated only by administrator actions, are usually predictable and controllable, and can be confined to established maintenance windows. Other virtual machine desktop power and refit operations are triggered by user behavior, such as using the Refresh on Logoff or Suspend on Logoff settings, or by scripted action, such as using Distributed Power Management (DPM) during windows of user inactivity to power off idle ESXi hosts.

If your Horizon 7 design does not require user-triggered power and refit operations, a single vCenter Server instance can probably suit your needs. Without a high frequency of user-triggered power and refit operations, no long queue of operations can accumulate that might cause Horizon Connection Server to time-out waiting for vCenter Server to complete the requested operations within the defined concurrency setting limits.

Many customers elect to deploy floating pools and use the Refresh on Logoff setting to consistently deliver desktops that are free of stale data from previous sessions. Examples of stale data include unclaimed memory pages in `pagefile.sys` or Windows temp files. Floating pools can also minimize the impact of malware by frequently resetting desktops to a known clean state.

Some customers are reducing electricity usage by configuring Horizon 7 to power off desktops not in use so that vSphere DRS (Distributed Resources Scheduler) can consolidate the running virtual machines onto a minimum number of ESXi hosts. VMware Distributed Power Management then powers off the idle hosts. In scenarios such as these, multiple vCenter Server instances can better accommodate the higher frequency of power and refit operations required to avoid operations time-outs.

Simplicity of Infrastructure

A single vCenter Server instance in a large-scale Horizon 7 design offers some compelling benefits, such as a single place to manage golden master images and parent virtual machines, a single vCenter Server view to match the Horizon Administrator console view, and fewer production back-end databases and database servers. Disaster Recovery planning is simpler for one vCenter Server than it is for multiple instances. Make sure you weigh the advantages of multiple vCenter Server instances, such as duration of maintenance windows and frequency of power and refit operations, against the disadvantages, such as the additional administrative overhead of managing parent virtual machine images and the increased number of infrastructure components required.

Your design might benefit from a hybrid approach. You can choose to have very large and relatively static pools managed by one vCenter Server instance and have several smaller, more dynamic desktop pools managed by multiple vCenter Server instances. The best strategy for upgrading existing large-scale pods is to first upgrade the VMware software components of your existing pod. Before changing your pod design, gauge the impact of the improvements of the latest version's power, provisioning, and refit operations, and later experiment with increasing the size of your desktop pools to find the right balance of more large desktop pools on fewer vCenter Server instances.

Planning for Security Features

Horizon 7 offers strong network security to protect sensitive corporate data. For added security, you can integrate Horizon 7 with certain third-party user-authentication solutions, use a security server, and implement the restricted entitlements feature.

Important Horizon 6 version 6.2 and later releases can perform cryptographic operations using FIPS (Federal Information Processing Standard) 140-2 compliant algorithms. You can enable the use of these algorithms by installing Horizon 7 in FIPS mode. Not all features are supported in FIPS mode. For more information, see the *Horizon 7 Installation* document.

This chapter includes the following topics:

- [Understanding Client Connections](#)
- [Choosing a User Authentication Method](#)
- [Restricting Remote Desktop Access](#)
- [Using Group Policy Settings to Secure Remote Desktops and Applications](#)
- [Using Smart Policies](#)
- [Implementing Best Practices to Secure Client Systems](#)
- [Assigning Administrator Roles](#)
- [Preparing to Use a Security Server](#)
- [Understanding Communications Protocols](#)

Understanding Client Connections

Horizon Client and Horizon Administrator communicate with a Horizon Connection Server host over secure HTTPS connections. Information about the server certificate on Connection Server is communicated to the client as part of the TLS handshake between client and server.

The initial Horizon Client connection, which is used for user authentication and remote desktop and application selection, is created when a user opens Horizon Client and provides a fully qualified domain name for the Connection Server, security server, or Unified Access Gateway host. The Horizon Administrator connection is created when an administrator types the Horizon Administrator URL into a Web browser.

A default TLS server certificate is generated during Connection Server installation. By default, TLS clients are presented with this certificate when they visit a secure page such as Horizon Administrator.

You can use the default certificate for testing, but you should replace it with your own certificate as soon as possible. The default certificate is not signed by a commercial Certificate Authority (CA). Use of non-certified certificates can allow untrusted parties to intercept traffic by masquerading as your server.

- **Client Connections Using the PCoIP and Blast Secure Gateways**

When clients connect to a remote desktop or application with the PCoIP or Blast Extreme display protocol from VMware, Horizon Client can make a second connection to the applicable Secure Gateway component on a Horizon Connection Server instance, security server, or Unified Access Gateway appliance. This connection provides the required level of security and connectivity when accessing remote desktops and applications from the Internet.

- **Tunneled Client Connections with Microsoft RDP**

When users connect to a remote desktop with the Microsoft RDP display protocol, Horizon Client can make a second HTTPS connection to the Horizon Connection Server host. This connection is called the tunnel connection because it provides a tunnel for carrying RDP data.

- **Direct Client Connections**

Administrators can configure Horizon Connection Server settings so that remote desktop and published application sessions are established directly between the client system and the published application or desktop virtual machine, bypassing the Connection Server host. This type of connection is called a direct client connection.

Client Connections Using the PCoIP and Blast Secure Gateways

When clients connect to a remote desktop or application with the PCoIP or Blast Extreme display protocol from VMware, Horizon Client can make a second connection to the applicable Secure Gateway component on a Horizon Connection Server instance, security server, or Unified Access Gateway appliance. This connection provides the required level of security and connectivity when accessing remote desktops and applications from the Internet.

Security servers and Unified Access Gateway appliances include a PCoIP Secure Gateway component and a Blast Secure Gateway component, which offers the following advantages:

- The only remote desktop and application traffic that can enter the corporate data center is traffic on behalf of a strongly authenticated user.
- Users can access only the resources that they are authorized to access.
- The PCoIP Secure Gateway connection supports PCoIP, and the Blast Secure Gateway connection supports Blast Extreme. Both are advanced remote display protocols that make more efficient use of the network by encapsulating video display packets in UDP instead of TCP.
- PCoIP and Blast Extreme are secured by AES-128 encryption by default. You can, however, change the encryption cipher to AES-256.

- No VPN is required, as long as the display protocol is not blocked by any networking component. For example, someone trying to access their remote desktop or application from inside a hotel room might find that the proxy the hotel uses is not configured to pass UDP packets.

For more information, see [Firewall Rules for DMZ-Based Security Servers](#).

Security servers run on Windows Server 2008 R2 and Windows Server 2012 R2 operating systems and take full advantage of the 64-bit architecture. This security server can also take advantage of Intel processors that support AES New Instructions (AESNI) for highly optimized encryption and decryption performance.

For more information about Unified Access Gateway virtual appliances, see *Deploying and Configuring Unified Access Gateway*.

Tunneled Client Connections with Microsoft RDP

When users connect to a remote desktop with the Microsoft RDP display protocol, Horizon Client can make a second HTTPS connection to the Horizon Connection Server host. This connection is called the tunnel connection because it provides a tunnel for carrying RDP data.

The tunnel connection offers the following advantages:

- RDP data is tunneled through HTTPS and is encrypted using SSL. This powerful security protocol is consistent with the security provided by other secure Web sites, such as those that are used for online banking and credit card payments.
- A client can access multiple desktops over a single HTTPS connection, which reduces the overall protocol overhead.
- Because Horizon 7 manages the HTTPS connection, the reliability of the underlying protocols is significantly improved. If a user temporarily loses a network connection, the HTTP connection is reestablished after the network connection is restored and the RDP connection automatically resumes without requiring the user to reconnect and log in again.

In a standard deployment of Connection Server instances, the HTTPS secure connection terminates at the Connection Server. In a DMZ deployment, the HTTPS secure connection terminates at a security server or Unified Access Gateway appliance. See [Preparing to Use a Security Server](#) for information on DMZ deployments and security servers.

Clients that use the PCoIP or Blast Extreme display protocol can use the tunnel connection for USB redirection and multimedia redirection (MMR) acceleration, but for all other data, PCoIP uses the PCoIP Secure Gateway, and Blast Extreme uses the Blast Secure Gateway, on a security server or Unified Access Gateway appliance. For more information, see [Client Connections Using the PCoIP and Blast Secure Gateways](#).

For more information about Unified Access Gateway virtual appliances, see *Deploying and Configuring Unified Access Gateway*.

Direct Client Connections

Administrators can configure Horizon Connection Server settings so that remote desktop and published application sessions are established directly between the client system and the published application or desktop virtual machine, bypassing the Connection Server host. This type of connection is called a direct client connection.

With direct client connections, an HTTPS connection is still made between the client and the Connection Server host for users to authenticate and select remote desktops and published applications, but the second HTTPS connection (the tunnel connection) is not used.

Direct PCoIP and Blast Extreme connections include the following built-in security features:

- Support for Advanced Encryption Standard (AES) encryption, which is turned on by default, and IP Security (IPsec)
- Support for third-party VPN clients

For clients that use the Microsoft RDP display protocol, direct client connections to remote desktops are appropriate only if your deployment is inside a corporate network. With direct client connections, RDP traffic is sent unencrypted over the connection between the client and the desktop virtual machine.

Choosing a User Authentication Method

Horizon 7 uses your existing Active Directory infrastructure for user authentication and management. For added security, you can integrate Horizon 7 with two-factor authentication solutions, such as RSA SecurID and RADIUS, and smart card authentication solutions.

- [Active Directory Authentication](#)

Each Horizon Connection Server instance is joined to an Active Directory domain, and users are authenticated against Active Directory for the joined domain. Users are also authenticated against any additional user domains with which a trust agreement exists.

- [Using Two-Factor Authentication](#)

You can configure a Horizon Connection Server instance so that users are required to use RSA SecurID authentication or RADIUS (Remote Authentication Dial-In User Service) authentication.

- [Smart Card Authentication](#)

A smart card is a small plastic card that is embedded with a computer chip. Many government agencies and large enterprises use smart cards to authenticate users who access their computer networks. One type of smart card used by the United States Department of Defense is called a Common Access Card (CAC).

- [Using the Log In as Current User Feature Available with Windows-Based Horizon Client](#)

With Horizon Client for Windows, when users select the **Log in as current user** check box, the credentials that they provided when logging in to the client system are used to authenticate to the Horizon Connection Server instance and to the remote desktop. No further user authentication is required.

Active Directory Authentication

Each Horizon Connection Server instance is joined to an Active Directory domain, and users are authenticated against Active Directory for the joined domain. Users are also authenticated against any additional user domains with which a trust agreement exists.

For example, if a Connection Server instance is a member of Domain A and a trust agreement exists between Domain A and Domain B, users from both Domain A and Domain B can connect to the Connection Server instance with Horizon Client.

Similarly, if a trust agreement exists between Domain A and an MIT Kerberos realm in a mixed domain environment, users from the Kerberos realm can select the Kerberos realm name when connecting to the Connection Server instance with Horizon Client.

You can place users and groups in the following Active Directory domains:

- The Connection Server domain
- A different domain that has a two-way trust relationship with the Connection Server domain
- A domain in a different forest than the Connection Server domain that is trusted by the Connection Server domain in a one-way external or realm trust relationship
- A domain in a different forest than the Connection Server domain that is trusted by the Connection Server domain in a one-way or two-way transitive forest trust relationship

Connection Server determines which domains are accessible by traversing trust relationships, starting with the domain in which the host resides. For a small, well-connected set of domains, Connection Server can quickly determine a full list of domains, but the time that it takes increases as the number of domains increases or as the connectivity between the domains decreases. The list might also include domains that you would prefer not to offer to users when they log in to their remote desktops and applications.

Administrators can use the `vdmadmin` command-line interface to configure domain filtering, which limits the domains that a Connection Server instance searches and that it displays to users. See the *Horizon 7 Administration* document for more information.

Policies, such as restricting permitted hours to log in and setting the expiration date for passwords, are also handled through existing Active Directory operational procedures.

Using Two-Factor Authentication

You can configure a Horizon Connection Server instance so that users are required to use RSA SecurID authentication or RADIUS (Remote Authentication Dial-In User Service) authentication.

- RADIUS support offers a wide range of alternative two-factor token-based authentication options.
- Horizon 7 also provides an open standard extension interface to allow third-party solution providers to integrate advanced authentication extensions into Horizon 7.

Because two-factor authentication solutions such as RSA SecurID and RADIUS work with authentication managers, installed on separate servers, you must have those servers configured and accessible to the Connection Server host. For example, if you use RSA SecurID, the authentication manager would be RSA Authentication Manager. If you have RADIUS, the authentication manager would be a RADIUS server.

To use two-factor authentication, each user must have a token, such as an RSA SecurID token, that is registered with its authentication manager. A two-factor authentication token is a piece of hardware or software that generates an authentication code at fixed intervals. Often authentication requires knowledge of both a PIN and an authentication code.

If you have multiple Connection Server instances, you can configure two-factor authentication on some instances and a different user authentication method on others. For example, you can configure two-factor authentication only for users who access remote desktops and applications from outside the corporate network, over the Internet.

Horizon 7 is certified through the RSA SecurID Ready program and supports the full range of SecurID capabilities, including New PIN Mode, Next Token Code Mode, RSA Authentication Manager, and load balancing.

Smart Card Authentication

A smart card is a small plastic card that is embedded with a computer chip. Many government agencies and large enterprises use smart cards to authenticate users who access their computer networks. One type of smart card used by the United States Department of Defense is called a Common Access Card (CAC).

Administrators can enable individual Connection Server instances for smart card authentication. Enabling a Connection Server instance to use smart card authentication typically involves adding your root certificate to a truststore file and then modifying Connection Server settings.

All client connections, including client connections that use smart card authentication, are TLS/SSL enabled.

To use smart cards, client machines must have smart card middleware and a smart card reader. To install certificates on smart cards, you must set up a computer to act as an enrollment station. For information about whether a particular type of Horizon Client supports smart cards, see the Horizon Client documentation at <https://docs.vmware.com/en/VMware-Horizon-Client/index.html>.

Using the Log In as Current User Feature Available with Windows-Based Horizon Client

With Horizon Client for Windows, when users select the **Log in as current user** check box, the credentials that they provided when logging in to the client system are used to authenticate to the Horizon Connection Server instance and to the remote desktop. No further user authentication is required.

To support this feature, user credentials are stored on both the Connection Server instance and on the client system.

- On the Connection Server instance, user credentials are encrypted and stored in the user session along with the username, domain, and optional UPN. The credentials are added when authentication occurs and are purged when the session object is destroyed. The session object is destroyed when the user logs out, the session times out, or authentication fails. The session object resides in volatile memory and is not stored in Horizon LDAP or in a disk file.
- On the client system, user credentials are encrypted and stored in a table in the Authentication Package, which is a component of Horizon Client. The credentials are added to the table when the user logs in and are removed from the table when the user logs out. The table resides in volatile memory.

Administrators can use Horizon Client group policy settings to control the availability of the **Log in as current user** check box and to specify its default value. Administrators can also use group policy to specify which Connection Server instances accept the user identity and credential information that is passed when users select the **Log in as current user** check box in Horizon Client.

The Recursive Unlock feature is enabled after a user logs in to Connection Server with the Log in as current user feature. The Recursive Unlock feature unlocks all remote sessions after the client machine has been unlocked. Administrators can control the Recursive Unlock feature with the **Unlock remote sessions when the client machine is unlocked** global policy setting in Horizon Client. For more information about global policy settings for Horizon Client, see the [Horizon Client documentation](#) at the [VMware Horizon Clients documentation](#) Web page.

The Log in as current user feature has the following limitations and requirements:

- When smart card authentication is set to Required on a Connection Server instance, authentication fails for users who select the **Log in as current user** check box when they connect to the Connection Server instance. These users must reauthenticate with their smart card and PIN when they log in to Connection Server.
- The time on the system where the client logs in and the time on the Connection Server host must be synchronized.
- If the default **Access this computer from the network** user-right assignments are modified on the client system, they must be modified as described in VMware Knowledge Base (KB) article 1025691.
- The client machine must be able to communicate with the corporate Active Directory server and not use cached credentials for authentication. For example, if users log in to their client machines from outside the corporate network, cached credentials are used for authentication. If the user then attempts to connect to a security server or a Connection Server instance without first establishing a VPN connection, the user is prompted for credentials, and the Log in as Current User feature does not work.

Restricting Remote Desktop Access

You can use the restricted entitlements feature to restrict remote desktop access based on the Horizon Connection Server instance that a user connects to.

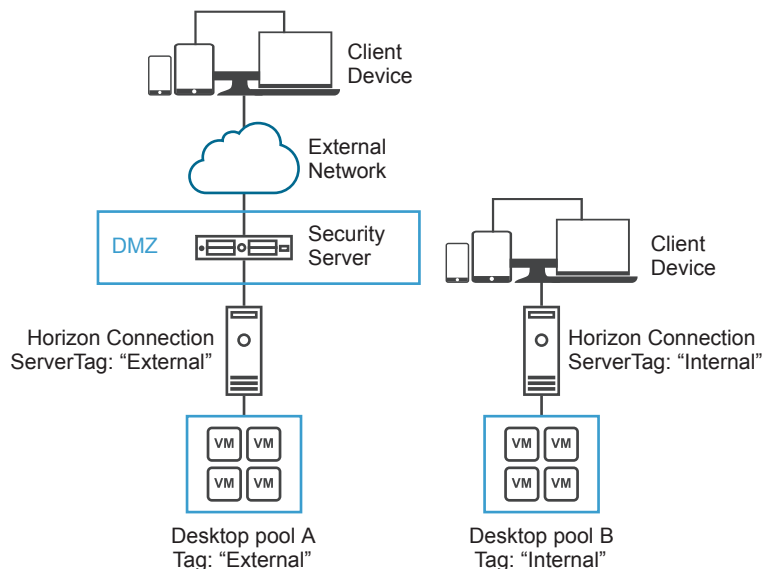
With restricted entitlements, you assign one or more tags to a Connection Server instance. Then, when configuring a desktop pool, you select the tags of the Connection Server instances that you want to be able to access the desktop pool. When users log in through a tagged Connection Server instance, they can access only those desktop pools that have at least one matching tag or no tags.

For example, your Horizon 7 deployment might include two Connection Server instances. The first instance supports your internal users. The second instance is paired with a security server and supports your external users. To prevent external users from accessing certain desktops, you could set up restricted entitlements as follows:

- Assign the tag "Internal" to the Connection Server instance that supports your internal users.
- Assign the tag "External" to the Connection Server instance that is paired with the security server and supports your external users.
- Assign the "Internal" tag to the desktop pools that should be accessible only to internal users.
- Assign the "External" tag to the desktop pools that should be accessible only to external users.

External users cannot see the desktop pools tagged as Internal because they log in through the Connection Server tagged as External, and internal users cannot see the desktop pools tagged as External because they log in through the Connection Server tagged as Internal. [Figure 5-1](#) illustrates this configuration.

Figure 5-1. Restricted Entitlements Example



You can also use restricted entitlements to control desktop access based on the user-authentication method that you configure for a particular Connection Server instance. For example, you can make certain desktop pools available only to users who have authenticated with a smart card.

The restricted entitlements feature only enforces tag matching. You must design your network topology to force certain clients to connect through a particular Connection Server instance.

Using Group Policy Settings to Secure Remote Desktops and Applications

Horizon 7 includes Group Policy administrative ADMX templates that contain security-related group policy settings that you can use to secure your remote desktops and applications.

For example, you can use group policy settings to perform the following tasks.

- Specify the Connection Server instances that can accept user identity and credential information that is passed when a user selects the **Log in as current user** check box in Horizon Client for Windows.
- Enable single sign-on for smart card authentication in Horizon Client.
- Configure server TLS certificate checking in Horizon Client.
- Prevent users from providing credential information with Horizon Client command line options.
- Prevent non-Horizon Client systems from using RDP to connect to remote desktops. You can set this policy so that connections must be Horizon Client-managed, which means that users must use Horizon 7 to connect to remote desktops.

See the *Configuring Remote Desktop Features in Horizon 7* document for information on using remote desktop and Horizon Client group policy settings.

Using Smart Policies

You can use Smart Policies to create policies that control the behavior of the USB redirection, virtual printing, clipboard redirection, client drive redirection, and PCoIP display protocol features on specific remote desktops. You can also use Smart Policies to create policies that control the behavior of published applications.

With Smart Policies, you can create policies that take effect only if certain conditions are met. For example, you can configure a policy that disables the client drive redirection feature if a user connects to a remote desktop from outside your corporate network.

The Smart Policies feature requires User Environment Manager. For more information, see the topics about Smart Policies in *Configuring Remote Desktop Features in Horizon 7*.

Implementing Best Practices to Secure Client Systems

Implement these best practices to secure client systems.

- Make sure that client systems are configured to go to sleep after a period of inactivity and require users to enter a password before the computer awakens.
- Require users to enter a username and password when starting client systems. Do not configure client systems to allow automatic logins.

- For Mac client systems, consider setting different passwords for the Keychain and the user account. When the passwords are different, users are prompted before the system enters any passwords on their behalf. Also consider turning on FileVault protection.

For a concise reference to all the security features Horizon 7 provides, see the *Horizon 7 Security* document.

Assigning Administrator Roles

A key management task in a Horizon 7 environment is to determine who can use Horizon Administrator and what tasks those users are authorized to perform.

The authorization to perform tasks in Horizon Administrator is governed by an access control system that consists of administrator roles and privileges. A role is a collection of privileges. Privileges grant the ability to perform specific actions, such as entitling a user to a desktop pool or changing a configuration setting. Privileges also control what an administrator can see in Horizon Administrator.

An administrator can create folders to subdivide desktop pools and delegate the administration of specific desktop pools to different administrators in Horizon Administrator. An administrator configures administrator access to the resources in a folder by assigning a role to a user on that folder.

Administrators can only access the resources that reside in folders for which they have assigned roles.

The role that an administrator has on a folder determines the level of access that the administrator has to the resources in that folder.

Horizon Administrator includes a set of predefined roles. Administrators can also create custom roles by combining selected privileges.

Preparing to Use a Security Server

A security server is a special instance of Horizon Connection Server that runs a subset of Connection Server functions. You can use a security server to provide an additional layer of security between the Internet and your internal network.

Important With Horizon 6 version 6.2 and later releases, you can use Unified Access Gateway appliances in place of security servers. Unified Access Gateway appliances are deployed as hardened virtual appliances, which are based on a Linux appliance that has been customized to provide secure access. For more information about Unified Access Gateway virtual appliances, see *Deploying and Configuring Unified Access Gateway*.

A security server resides within a DMZ and acts as a proxy host for connections inside your trusted network. Each security server is paired with an instance of Connection Server and forwards all traffic to that instance. You can pair multiple security servers to a single connection server. This design provides an additional layer of security by shielding the Connection Server instance from the public-facing Internet and by forcing all unprotected session requests through the security server.

A DMZ-based security server deployment requires a few ports to be opened on the firewall to allow clients to connect with security servers inside the DMZ. You must also configure ports for communication between security servers and the Connection Server instances in the internal network. See [Firewall Rules for DMZ-Based Security Servers](#) for information on specific ports.

Because users can connect directly with any Connection Server instance from within their internal network, you do not need to implement a security server in a LAN-based deployment.

Note Security servers include a PCoIP Secure Gateway component and a Blast Secure Gateway component so that clients that use the PCoIP or Blast Extreme display protocol can use a security server rather than a VPN.

For information about setting up VPNs for using PCoIP, see the VPN solution overviews, available in the Technology Partner Resources section of the Technical Resource Center at <http://www.vmware.com/products/view/resources.html>.

Best Practices for Security Server Deployments

Follow these best practice security policies and procedures when operating a security server in a DMZ.

The *DMZ Virtualization with VMware Infrastructure* white paper includes examples of best practices for a virtualized DMZ. Many of the recommendations in this white paper also apply to a physical DMZ.

To limit the scope of frame broadcasts, the Horizon Connection Server instances that are paired with security servers should be deployed on an isolated network. This topology can help prevent a malicious user on the internal network from monitoring communication between the security servers and Connection Server instances.

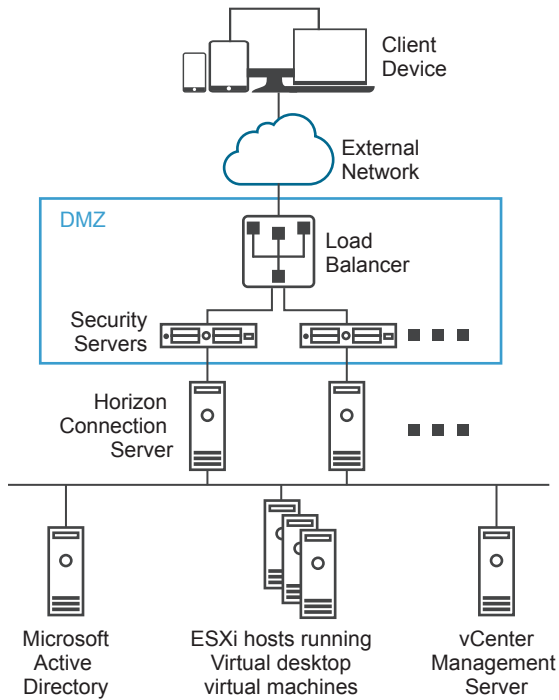
Alternatively, you might be able to use advanced security features on your network switch to prevent malicious monitoring of security server and Connection Server communication and to guard against monitoring attacks such as ARP Cache Poisoning. See the administration documentation for your networking equipment for more information.

Security Server Topologies

You can implement several different security server topologies.

The topology illustrated in [Figure 5-2](#) shows a high-availability environment that includes two load-balanced security servers in a DMZ. The security servers communicate with two Horizon Connection Server instances inside the internal network.

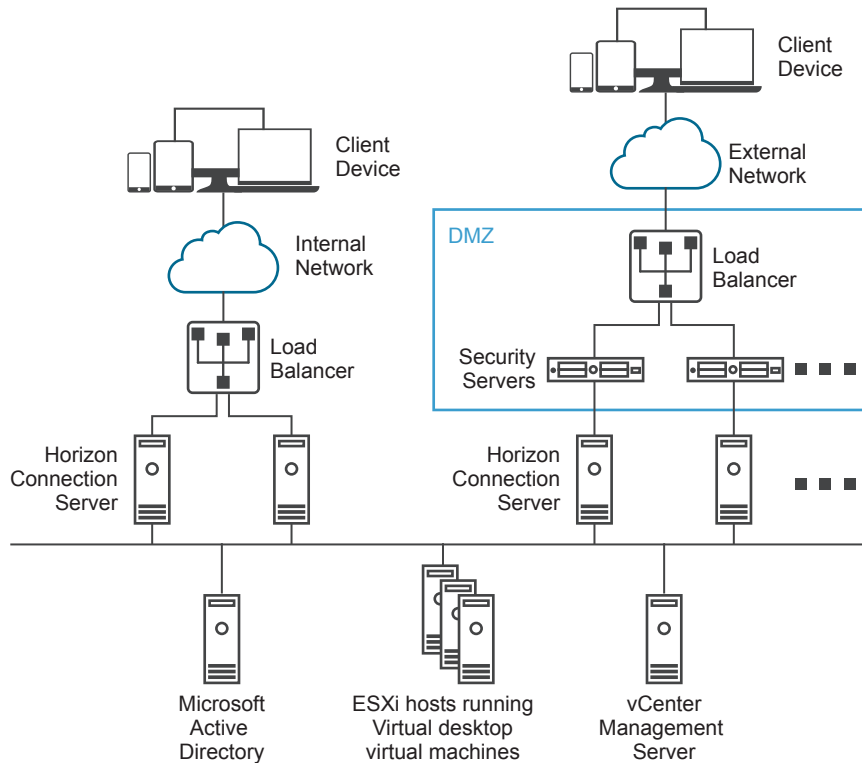
Figure 5-2. Load-Balanced Security Servers in a DMZ



When users outside the corporate network connect to a security server, they must successfully authenticate before they can access remote desktops and applications. With appropriate firewall rules on both sides of the DMZ, this topology is suitable for accessing remote desktops and applications from client devices located on the Internet.

You can connect multiple security servers to each instance of Connection Server. You can also combine a DMZ deployment with a standard deployment to offer access for internal users and external users.

The topology illustrated in [Figure 5-3](#) shows an environment where four instances of Connection Server act as one group. The instances in the internal network are dedicated to users of the internal network, and the instances in the external network are dedicated to users of the external network. If the Connection Server instances paired with the security servers are enabled for RSA SecurID authentication, all external network users are required to authenticate by using RSA SecurID tokens.

Figure 5-3. Multiple Security Servers

You must implement a hardware or software load balancing solution if you install more than one security server. Connection Server does not provide its own load balancing functionality. Connection Server works with standard third-party load balancing solutions.

Firewalls for DMZ-Based Security Servers

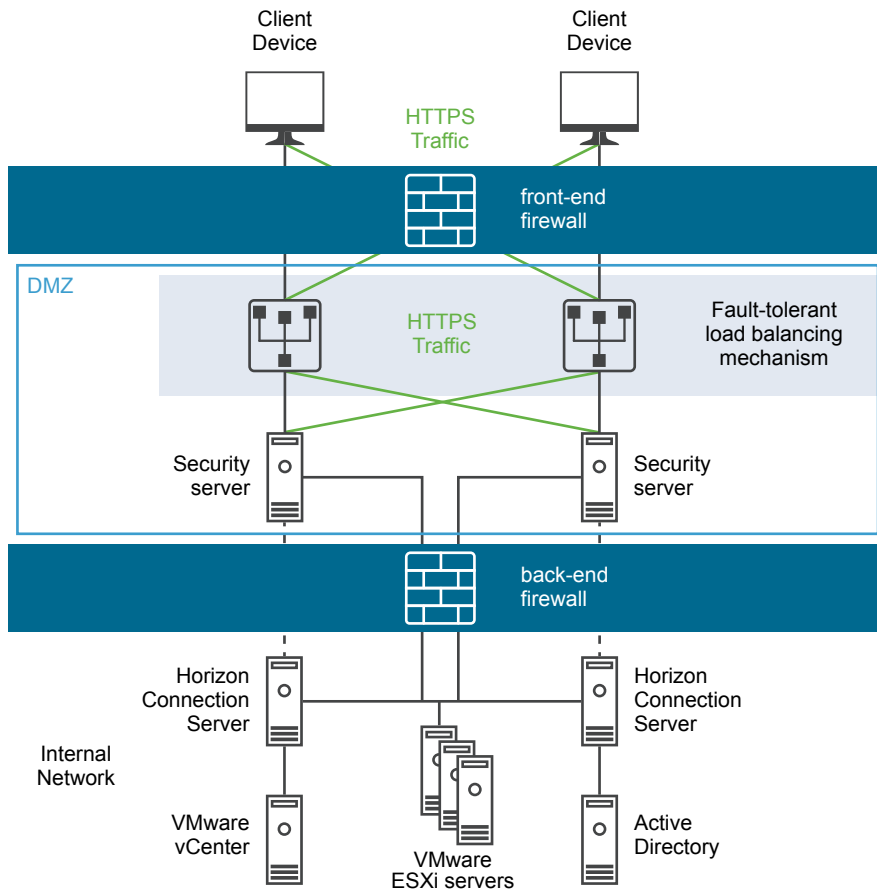
A DMZ-based security server deployment must include two firewalls.

- An external network-facing, front-end firewall is required to protect both the DMZ and the internal network. You configure this firewall to allow external network traffic to reach the DMZ.
- A back-end firewall, between the DMZ and the internal network, is required to provide a second tier of security. You configure this firewall to accept only traffic that originates from the services within the DMZ.

Firewall policy strictly controls inbound communications from DMZ services, which greatly reduces the risk of compromising your internal network. For more information about ports required to configure security servers, see the *Horizon 7 Security* document.

The following figure shows an example of a configuration that includes front-end and back-end firewalls.

Figure 5-4. Dual Firewall Topology



Firewall Rules for DMZ-Based Security Servers

DMZ-based security servers require certain firewall rules on the front-end and back-end firewalls. During installation, Horizon 7 services are set up to listen on certain network ports by default. If necessary, to comply with organization policies or to avoid contention, you can change which port numbers are used.

Important For additional details and security recommendations, see the *Horizon 7 Security* document.

Front-End Firewall Rules

To allow external client devices to connect to a security server within the DMZ, the front-end firewall must allow traffic on certain TCP and UDP ports. [Table 5-1](#) summarizes the front-end firewall rules.

Table 5-1. Front-End Firewall Rules

Source	Default Port	Protocol	Destination	Default Port	Notes
Horizon Client	TCP Any	HTTP	Security Server	TCP 80	(Optional) External client devices connect to a security server within the DMZ on TCP port 80 and are automatically directed to HTTPS. For information about the security considerations related to letting users connect with HTTP rather than HTTPS, see the <i>Horizon 7 Security</i> guide.
Horizon Client	TCP Any	HTTPS	Security server	TCP 443	External client devices connect to a security server within the DMZ on TCP port 443 to communicate with a Connection Server instance and remote desktops and applications.
Horizon Client	TCP Any UDP Any	PCoIP	Security server	TCP 4172 UDP 4172	External client devices connect to a security server within the DMZ on TCP port 4172 and UDP port 4172 to communicate with a remote desktop or application over PCoIP.
Security Server	UDP 4172	PCoIP	Horizon Client	UDP Any	Security servers send PCoIP data back to an external client device from UDP port 4172. The destination UDP port is the source port from the received UDP packets. Because these packets contain reply data, it is normally unnecessary to add an explicit firewall rule for this traffic.
Horizon Client or Client Web browser	TCP Any	HTTPS	Security server	TCP 8443 UDP 8443	External client devices and external Web clients (HTML Access) connect to a security server within the DMZ on HTTPS port 8443 to communicate with remote desktops.

Back-End Firewall Rules

To allow a security server to communicate with each View Connection Server instance that resides within the internal network, the back-end firewall must allow inbound traffic on certain TCP ports. Behind the back-end firewall, internal firewalls must be similarly configured to allow remote desktops applications and Connection Server instances to communicate with each other. [Table 5-2](#) summarizes the back-end firewall rules.

Table 5-2. Back-End Firewall Rules

Source	Default Port	Protocol	Destination	Default Port	Notes
Security server	UDP 500	IPSec	Connection Server	UDP 500	Security servers negotiate IPSec with Connection Server instances on UDP port 500.
Connection Server	UDP 500	IPSec	Security server	UDP 500	Connection Server instances respond to security servers on UDP port 500.
Security Server	UDP 4500	NAT-T ISAKMP	Connection Server	UDP 4500	Required if NAT is used between a security server and its paired Connection Server instance. Security servers use UDP port 4500 to traverse NATs and negotiate IPsec security.
Connection Server	UDP 4500	NAT-T ISAKMP	Security server	UDP 4500	Connection Server instances respond to security servers on UDP port 4500 if NAT is used.

Table 5-2. Back-End Firewall Rules (Continued)

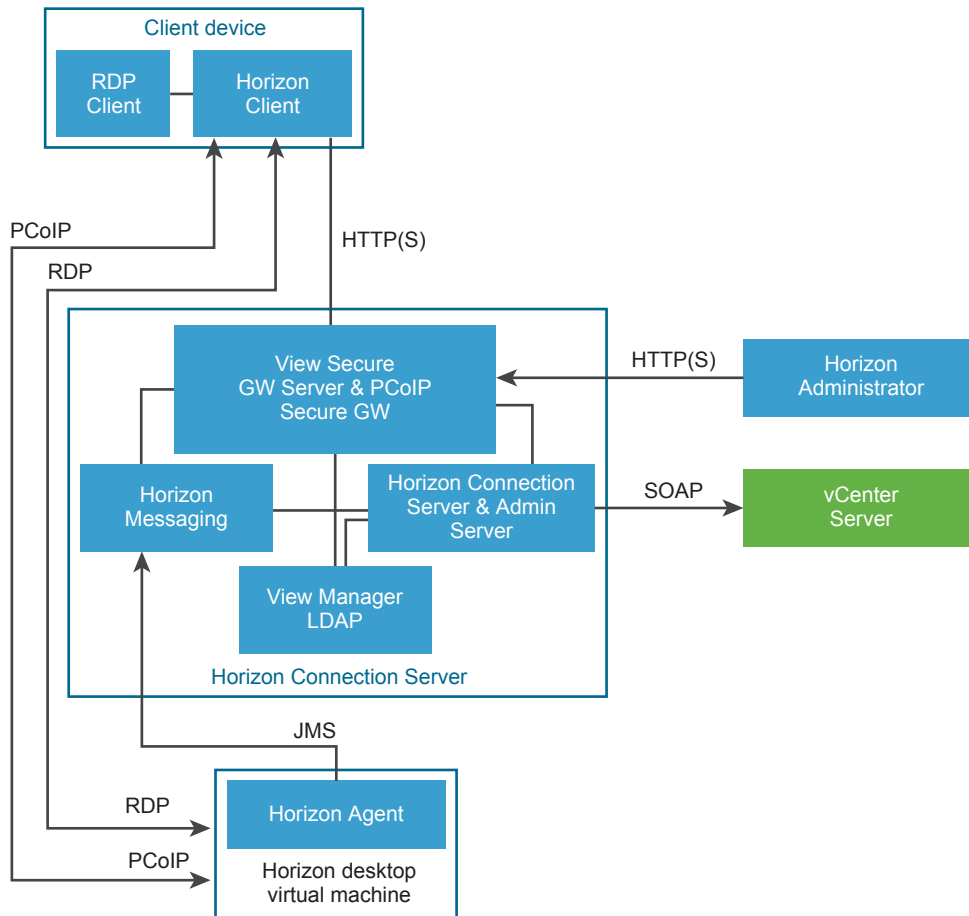
Source	Default Port	Protocol	Destination	Default Port	Notes
Security server	TCP Any	AJP13	Connection Server	TCP 8009	Security servers connect to Connection Server instances on TCP port 8009 to forward Web traffic from external client devices. If you enable IPSec, AJP13 traffic does not use TCP port 8009 after pairing. Instead it flows over either NAT-T (UDP port 4500) or ESP.
Security server	TCP Any	JMS	Connection Server	TCP 4001	Security servers connect to Connection Server instances on TCP port 4001 to exchange Java Message Service (JMS) traffic.
Security server	TCP Any	JMS	Connection Server	TCP 4002	Security servers connect to Connection Server instances on TCP port 4002 to exchange secure Java Message Service (JMS) traffic.
Security server	TCP Any	RDP	Remote desktop	TCP 3389	Security servers connect to remote desktops on TCP port 3389 to exchange RDP traffic.
Security server	TCP Any	MMR	Remote desktop	TCP 9427	Security servers connect to remote desktops on TCP port 9427 to receive traffic relating to multimedia redirection (MMR) and client drive redirection.
Security server	TCP Any UDP 55000	PCoIP	Remote desktop or application	TCP 4172 UDP 4172	Security servers connect to remote desktops and applications on TCP port 4172 and UDP port 4172 to exchange PCoIP traffic.
Remote desktop or application	UDP 4172	PCoIP	Security server	UDP 55000	Remote desktops and applications send PCoIP data back to a security server from UDP port 4172 . The destination UDP port will be the source port from the received UDP packets and so as this is reply data, it is normally unnecessary to add an explicit firewall rule for this.
Security server	TCP Any	USB-R	Remote desktop	TCP 32111	Security servers connect to remote desktops on TCP port 32111 to exchange USB redirection traffic between an external client device and the remote desktop.
Security server	TCP or UDP Any	Blast Extreme	Remote desktop or application	TCP or UDP 22443	Security servers connect to remote desktops and applications on TCP and UDP port 22443 to exchange Blast Extreme traffic.
Security server	TCP Any	HTTPS	Remote desktop	TCP 22443	If you use HTML Access, security servers connect to remote desktops on HTTPS port 22443 to communicate with the Blast Extreme agent.
Security server		ESP	Connection Server		Encapsulated AJP13 traffic when NAT traversal is not required. ESP is IP protocol 50. Port numbers are not specified.
Connection Server		ESP	Security server		Encapsulated AJP13 traffic when NAT traversal is not required. ESP is IP protocol 50. Port numbers are not specified.

Understanding Communications Protocols

Horizon 6 and Horizon 7 components exchange messages by using several different protocols.

Figure 5-5 illustrates the protocols that each component uses for communication when a security server is not configured. That is, the secure tunnel for RDP, the Blast Secure Gateway, and the PCoIP Secure Gateway are not turned on. This configuration might be used in a typical LAN deployment.

Figure 5-5. Horizon 6 and Horizon 7 Components and Protocols Without a Security Server



Note This figure shows direct connections for clients using either PCoIP or RDP. The default setting, however, is to have direct connections for PCoIP and tunnel connections for RDP.

See Table 5-3 for the default ports that are used for each protocol.

Figure 5-6 illustrates the protocols that each component uses for communication when a security server is configured. This configuration might be used in a typical WAN deployment.

Figure 5-6. Horizon 6 and Horizon 7 Components and Protocols with a Security Server

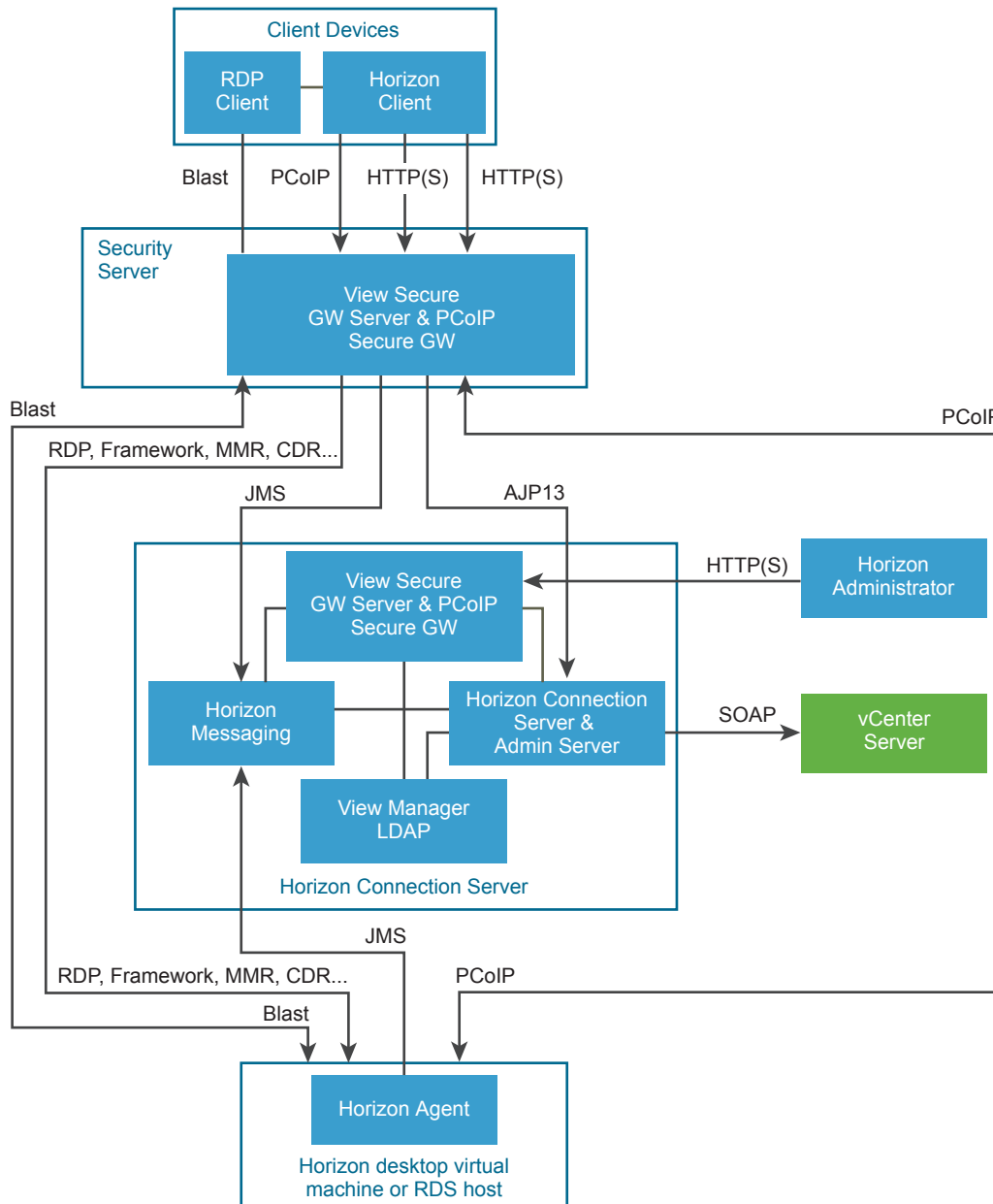


Table 5-3 lists the default ports that are used by each protocol. If necessary, to comply with organization policies or to avoid contention, you can change which port numbers are used.

Table 5-3. Default Ports

Protocol	Port
JMS	TCP port 4001 TCP port 4002
AJP13	TCP port 8009
Note AJP13 is used in a security server configuration only.	
HTTP	TCP port 80

Table 5-3. Default Ports (Continued)

Protocol	Port
HTTPS	TCP port 443
MMR/CDR	For multimedia redirection and client drive redirection, TCP port 9427
RDP	TCP port 3389 Note If the Connection Server instance is configured for direct client connections, these protocols connect directly from the client to the remote desktop and are not tunneled through the View Secure GW Server component.
SOAP	TCP port 80 or 443
PCoIP	TCP port 4172 UDP ports 4172, 50002, 55000
USB redirection	TCP port 32111. This port is also used for time zone synchronization.
VMware Blast Extreme	TCP ports 8443, 22443 UDP ports 443, 8443, 22443
HTML Access	TCP ports 8443, 22443

TCP Ports for Connection Server Intercommunication

Connection Server instances in a group use additional TCP ports to communicate with each other. For example, Connection Server instances use port 4100 or 4101 to transmit JMS inter-router (JMSIR) traffic to each other. Firewalls are generally not used between the Connection Server instances in a group.

View Secure Gateway Server

View Secure Gateway Server is the server-side component for the secure HTTPS connection between client systems and a security server, Unified Access Gateway appliance, or Connection Server instance.

When you configure the tunnel connection for Connection Server, RDP, USB, and Multimedia Redirection (MMR) traffic is tunneled through the View Secure Gateway component. When you configure direct client connections, these protocols connect directly from the client to the remote desktop and are not tunneled through the View Secure Gateway Server component.

Note Clients that use the PCoIP or Blast Extreme display protocol can use the tunnel connection for USB redirection and multimedia redirection (MMR) acceleration, but for all other data, PCoIP uses the PCoIP Secure Gateway, and Blast Extreme uses the Blast Secure Gateway, on a security server or Unified Access Gateway appliance.

View Secure Gateway Server is also responsible for forwarding other Web traffic, including user authentication and desktop and application selection traffic, from clients to Connection Server. View Secure Gateway Server also passes Horizon Administrator client Web traffic to the Administration Server component.

Blast Secure Gateway

Security servers and Unified Access Gateway appliances include a Blast Secure Gateway component. When the Blast Secure Gateway is enabled, after authentication, clients that use Blast Extreme or HTML Access can make another secure connection to a security server or Unified Access Gateway appliance. This connection allows clients to access remote desktops and applications from the Internet.

When you enable the Blast Secure Gateway component, Blast Extreme traffic is forwarded by a security server or Unified Access Gateway appliance to remote desktops and applications. If clients that use Blast Extreme also use the USB redirection feature or multimedia redirection (MMR) acceleration, you can enable the View Secure Gateway component in order to forward that data.

When you configure direct client connections, Blast Extreme traffic and other traffic goes directly from a client to a remote desktop or application.

When end users such as home or mobile workers access desktops from the Internet, security servers or Unified Access Gateway appliances provide the required level of security and connectivity so that a VPN connection is not necessary. The Blast Secure Gateway component ensures that the only remote traffic that can enter the corporate data center is traffic on behalf of a strongly authenticated user. End users can access only the resources that they are authorized to access.

PCoIP Secure Gateway

Security servers and Unified Access Gateway appliances include a PCoIP Secure Gateway component. When the PCoIP Secure Gateway is enabled, after authentication, clients that use PCoIP can make another secure connection to a security server or Unified Access Gateway appliance. This connection allows clients to access remote desktops and applications from the Internet.

When you enable the PCoIP Secure Gateway component, PCoIP traffic is forwarded by a security server or Unified Access Gateway appliance to remote desktops and applications. If clients that use PCoIP also use the USB redirection feature or multimedia redirection (MMR) acceleration, you can enable the View Secure Gateway component in order to forward that data.

When you configure direct client connections, PCoIP traffic and other traffic goes directly from a client to a remote desktop or application.

When end users such as home or mobile workers access desktops from the Internet, security servers or Unified Access Gateway appliances provide the required level of security and connectivity so that a VPN connection is not necessary. The PCoIP Secure Gateway component ensures that the only remote traffic that can enter the corporate data center is traffic on behalf of a strongly authenticated user. End users can access only the resources that they are authorized to access.

View LDAP

View LDAP is an embedded LDAP directory in View Connection Server and is the configuration repository for all Horizon 7 configuration data.

View LDAP contains entries that represent each remote desktop and application, each accessible remote desktop, multiple remote desktops that are managed together, and Horizon 7 component configuration settings.

View LDAP also includes a set of Horizon 7 plug-in DLLs to provide automation and notification services for other Horizon 7 components.

Horizon Messaging

The Horizon Messaging component provides the messaging router for communication between Horizon Connection Server components and between Horizon Agent and Connection Server.

This component supports the Java Message Service (JMS) API, which is used for messaging in Horizon 7.

Intercomponent message validation uses DSA keys. The key size is 512 bits by default, except in FIPS mode, where the key size is 2048 bits.

Note When the message security mode is set to **Enhanced**, SSL/TLS is used to secure JMS connections rather than using per-message encryption. In enhanced message security mode, validation applies to only one message type. For enhanced message mode, VMware recommends increasing the key size to 2048 bits. If you are not using enhanced message security mode, VMware recommends not changing the default from 512 bits because increasing the key size affects performance and scalability.

If you want all keys to be 1024 bits, the RSA key size must be changed immediately after the first Connection Server instance is installed and before additional servers and desktops are created. See VMware Knowledge Base (KB) article 1024431 for more information.

Firewall Rules for Horizon Connection Server

Certain ports must be opened on the firewall for Connection Server instances and security servers.

When you install Connection Server, the installation program can optionally configure the required Windows Firewall rules for you. These rules open the ports that are used by default. If you change the default ports after installation, you must manually configure Windows Firewall to allow Horizon Client devices to connect to Horizon 7 through the updated ports.

The following table lists the default ports that can be opened automatically during installation. Ports are incoming unless otherwise noted.

Table 5-4. Ports Opened During Horizon Connection Server Installation

Protocol	Ports	Horizon Connection Server Instance Type
JMS	TCP 4001	Standard and replica
JMS	TCP 4002	Standard and replica
JMSIR	TCP 4100	Standard and replica
JMSIR	TCP 4101	Standard and replica
AJP13	TCP 8009	Standard and replica

Table 5-4. Ports Opened During Horizon Connection Server Installation (Continued)

Protocol	Ports	Horizon Connection Server Instance Type
HTTP	TCP 80	Standard, replica, and security server
HTTPS	TCP 443	Standard, replica, and security server
PCoIP	TCP 4172 in; UDP 4172 both directions	Standard, replica, and security server
HTTPS	TCP 8443 UDP 8443	Standard, replica, and security server. After the initial connection to Horizon 7 is made, the Web browser or client device connects to the Blast Secure Gateway on TCP port 8443. The Blast Secure Gateway must be enabled on a security server or View Connection Server instance to allow this second connection to take place.
HTTPS	TCP 8472	Standard and replica For the Cloud Pod Architecture feature: used for interpod communication.
HTTP	TCP 22389	Standard and replica For the Cloud Pod Architecture feature: used for global LDAP replication.
HTTPS	TCP 22636	Standard and replica For the Cloud Pod Architecture feature: used for secure global LDAP replication.

Firewall Rules for View Agent or Horizon Agent

The View Agent and Horizon Agent installers optionally configure Windows firewall rules on remote desktops and RDS hosts to open the default network ports. Ports are incoming unless otherwise noted.

The View Agent and Horizon Agent installers configure the local firewall rule for inbound RDP connections to match the current RDP port of the host operating system, which is typically 3389.

If you instruct the View Agent or Horizon Agent installer not to enable Remote Desktop support, it does not open ports 3389 and 32111, and you must open these ports manually.

If you change the RDP port number after installation, you must change the associated firewall rules. If you change a default port after installation, you must manually reconfigure Windows firewall rules to allow access on the updated port. See "Replacing Default Ports for View Services" in the *Horizon 7 Installation* document.

Windows firewall rules for View Agent or Horizon Agent on RDS hosts show a block of 256 contiguous UDP ports as open for inbound traffic. This block of ports is for VMware Blast internal use in View Agent or Horizon Agent. A special Microsoft-signed driver on RDS hosts blocks inbound traffic to these ports from external sources. This driver causes the Windows firewall to treat the ports as closed.

If you use a virtual machine template as a desktop source, firewall exceptions carry over to deployed desktops only if the template is a member of the desktop domain. You can use Microsoft group policy settings to manage local firewall exceptions. See the Microsoft Knowledge Base (KB) article 875357 for more information.

Table 5-5. TCP and UDP Ports Opened During View Agent or Horizon Agent Installation

Protocol	Ports
RDP	TCP port 3389
USB redirection and time zone synchronization	TCP port 32111
MMR (multimedia redirection) and CDR (client drive redirection)	TCP port 9427
PCoIP	<p>For RDS hosts, PCoIP uses the following port numbers: TCP port 4172 and UDP port 4172 (bidirectional).</p> <p>For desktops, PCoIP uses port numbers chosen from a configurable range. By default, TCP ports 4172 to 4173 and UDP ports 4172 to 4182. The firewall rules for these do not specify port numbers but dynamically follow the ports opened by each PCoIP Server. The chosen port numbers are communicated to the client via the Connection Server.</p>
VMware Blast	<p>TCP port 22443</p> <p>UDP port 22443 (bidirectional)</p> <p>Note UDP is not used on Linux desktops.</p>
HTML Access	TCP port 22443

Firewall Rules for Active Directory

If you have a firewall between your Horizon 7 environment and your Active Directory server, you must make sure that all of the necessary ports are opened.

For example, View Connection Server must be able to access the Active Directory Global Catalog and Lightweight Directory Access Protocol (LDAP) servers. If the Global Catalog and LDAP ports are blocked by your firewall software, administrators will have problems configuring user entitlements.

See the Microsoft documentation for your Active Directory server version for information about the ports that must be opened for Active Directory to function correctly through a firewall.

Overview of Steps to Setting Up a Horizon 7 Environment

6

Complete these high-level tasks to install Horizon 7 and configure an initial deployment.

Table 6-1. Horizon 7 Installation and Setup Check List

Step	Task
1	Set up the required administrator users and groups in Active Directory. Instructions: <i>Horizon 7 Installation</i> and vSphere documentation.
2	If you have not yet done so, install and set up ESXi hosts and vCenter Server. Instructions: VMware vSphere documentation.
3	(Optional) If you are going to deploy linked-clone desktops, install View Composer, either on the vCenter Server system or on a separate server. Also install the View Composer database. Instructions: <i>Horizon 7 Installation</i> document.
4	Install and set up Horizon Connection Server. Also install the Events database. Instructions: <i>Horizon 7 Installation</i> document.
5	Create one or more virtual machines that can be used as a template for full-clone desktop pools or as a parent for linked-clone desktop pools or instant clone desktop pools. Instructions: <i>Setting Up Virtual Desktops in Horizon 7</i> .
6	(Optional) Set up an RDS host and install applications to be remoted to end users. Instructions: <i>Setting Up Published Desktops and Applications in Horizon 7</i> .
7	Create desktop pools, application pools, or both. Instructions: <i>Setting Up Virtual Desktops in Horizon 7</i> and <i>Setting Up Published Desktops and Applications in Horizon 7</i> .
8	Control user access to desktops. Instructions: <i>Configuring Remote Desktop Features in Horizon 7</i> .
9	Install Horizon Client on end users' machines and have end users access their remote desktops and applications. Instructions: Horizon Client documentation at https://docs.vmware.com/en/VMware-Horizon-Client/index.html .
10	(Optional) Create and configure additional administrators to allow different levels of access to specific inventory objects and settings. Instructions: <i>Horizon 7 Administration</i> document.
11	(Optional) Configure policies to control the behavior of Horizon 7 components, desktop and application pools, and end users. Instructions: <i>Configuring Remote Desktop Features in Horizon 7</i> .

Table 6-1. Horizon 7 Installation and Setup Check List (Continued)

Step	Task
12	(Optional) Configure Horizon Persona Management, which gives users access to personalized data and settings whenever they log in to a desktop. Instructions: <i>Setting Up Virtual Desktops in Horizon 7</i> .
13	(Optional) For added security, integrate smart card authentication or a RADIUS two-factor authentication solution. Instructions: <i>Horizon 7 Administration</i> document.