Cisco HyperFlex Systems

Cisco HyperFlex HX220c M4 Node for Virtual Desktop Infrastructure with Citrix XenDesktop and Citrix Provisioning Services

Intel Broadwell Processors, Windows 10 and Citrix MCS Update

October 2016

This white paper describes the Cisco HyperFlex Systems™ hyperconverged virtualized infrastructure solution.
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Executive Summary

The lack of a simple and efficient IT platform designed for easy consumption by application workloads is adding to the cost of doing business. Cisco HyperFlex Systems™ addresses this need while also including the desirable features of flexibility and consistent management.

Cutting the deployment time of the required compute, storage and network infrastructure for desktop virtualization to two hours or less is an order of magnitude faster than typical two week deployment times for some converged systems.

When using Citrix XenDesktop as the broker for virtual desktop infrastructure (VDI,) Cisco recommends using Citrix Provisioning Services (PVS) for pooled, non-persistent Microsoft Windows virtual desktops and for virtual Citrix XenApp servers. Our studies have found that PVS delivers optimal boot times and end user experience for scales over 500 seats.

Citrix PVS allows the near immediate use of new capacity as it is brought online and provides seamless desktop image maintenance.

Citrix XenDesktop performance on HyperFlex provides industry leading baseline and sustained Login VSI response times, 2.5 times faster than the leading hyperconverged competitor.1 End users can expect one second or less response times with the cluster at full 1000 user load.

We have updated the original release of this paper to include performance data for recently released Intel Broadwell processors and faster memory, for Windows 10 and Office 2016 workload and for Citrix Machine Creation services.

It is clear that Cisco HyperFlex delivers industry leading end-user experience for Citrix XenDesktop virtual desktop users on the latest desktop operating system and office suite on the customer’s provisioning platform of choice.

Reference Architecture Overview

This section defines current IT Infrastructure challenges and presents a high-level view of the solution and its benefits.

Document Purpose

This document describes a virtualized solution platform with eight Cisco HyperFlex HX220c M4 Nodes for up to 1000 Citrix XenDesktop virtual desktops. It provides design and sizing guidelines to help you build solution platforms similar to the one tested. This document is not intended to be a comprehensive guide to every aspect of this solution.

Solution Purpose

Cisco HyperFlex Systems are built on the Cisco Unified Computing System™ (Cisco UCS®) platform. They offer faster deployment and greater flexibility and efficiency at a competitive price while lowering risk for the customer. Proven components from Cisco are integrated to form a software-defined storage (SDS) platform. This approach eliminates or reduces the need for planning and configuration decisions, while allowing customization to meet customer workload needs. The platform and management model adopted is an extension of the established Cisco

1 Comparing Login VSI analyzer baseline response times of Cisco UCS HyperFlex running Citrix XenDesktop 7.8 as detailed in this paper with data from the Nutanix Citrix XenDesktop on AHV, Nutanix Reference Architecture, Version 2.0, May 2016, RA-2035.
UCS data center strategy, with familiar components managed in a consistent manner through a policy-based framework using Cisco UCS Manager.

Business Challenges
An efficient IT Infrastructure is integral to the initial success and continued competitiveness of most businesses. IT efficiency can be expressed in capital and operating costs to the business. Two major components of operating costs for all businesses are human resources and optimal utilization of purchased IT resources.

The underlying issues that contribute to these operating costs are as follows:

- **Complexity**: Complex systems take longer to deploy and require a greater number of highly skilled technical staff members. The multitude of technologies and tools required to keep the infrastructure running and the nonstandard methods introduced by this approach have a direct effect on failure rates, contributing to even more costs to the business.

- **Stranded capacity**: Even with virtualization, IT resource consumption is not optimal. The business requirements and computing and storage needs of workloads change over time, potentially resulting in unused computing or storage resources in the enterprise. One way to prevent this underutilization of resources is to introduce flexibility into the architecture so that you can expand computing and storage resources independently.

Efforts to reduce management complexity through consolidation of native element managers on preintegrated and converged IT infrastructure have resulted in only limited improvements. These factors and the short depreciation cycles of capitalized IT resources point to the need for simpler and more precisely controlled components to achieve necessary levels of utilization.

The Solution
The Cisco HyperFlex solution focuses on simplicity of deployment and operation. It delivers a hyperconverged platform that has the advantage of allowing you to start small and grow in small increments without the need for expensive storage devices connected to computing resources by either SAN or network-attached storage (NAS) methods. A basic cluster requires three hyperconverged nodes managed by Cisco UCS Manager. Beyond this, a Cisco HyperFlex cluster can increase computing and storage resources for flexible scaling according to workload needs. Flexibility is introduced by creating a cluster with a mix of Cisco UCS B200 M4 Blade Servers as computing-only nodes connected to a set of Cisco HyperFlex HX240c M4 Nodes operating as hyperconverged nodes. In this scenario, the hyperconverged node provides storage for the Cisco UCS B200 M4 computing-only nodes. This feature allows either storage or computing capacity to be added independently to achieve optimal levels of cluster resources.

The Cisco HyperFlex solution also delivers storage efficiency features such as thin provisioning, data deduplication, and compression for greater capacity and performance improvements. Additional operational efficiency is facilitated through features such as cloning and snapshots.

This solution uses Cisco HyperFlex HX220c M4 Nodes, Cisco UCS fabric interconnects, Cisco UCS Manager, Cisco Nexus® 9372 platform switches, Cisco HyperFlex HX Data Platform (SDS) software, Citrix XenDesktop Version 7.8, and the VMware ESXi 6.0 Update 1b hypervisor. The HX220c M4 Nodes provide computing, cache, and storage resources and are centrally managed by Cisco UCS Manager. The HX Data Platform software serves computing and networking resources and a shared pool of storage resources from separate Cisco HyperFlex HX-
Series nodes for consumption by a mix of workloads. This SDS platform is managed by the VMware vSphere web client plug-in.

**Solution Benefits**

This solution provides the following benefits to customers:

- **Simplicity:** The solution is designed to be deployed and managed easily and quickly through familiar tools and methods. No separate management console is required for the Cisco HyperFlex solution.

- **Centralized hardware management:** The cluster hardware is managed in a consistent manner by service profiles in Cisco UCS Manager. Cisco UCS Manager also provides single-point console and firmware management capabilities. Cisco HyperFlex HX Data Platform (SDS) clusters are managed through a plug-in to VMware vCenter.

- **High availability:** Component redundancy is built in to most levels at the node. Cluster-level tolerance to node, network, and fabric interconnect failures is implemented as well.

- **Efficiency:** Complementing the other management efficiencies are features such as thin provisioning, data deduplication, compression, cloning, and snapshots to address concerns related to overprovisioning of storage.

- **Flexibility—“pay as you grow”:** Customers can purchase the exact amount of computing and storage they need and expand one node at a time up to the supported cluster node limit.

- **Mobile workspace solution:** Citrix XenDesktop provides a best-in-class desktop and application virtualization solution, managed from a single console, providing anywhere, anytime access to users on any device.

Customers who have already invested in Cisco® products and technologies have the opportunity to mitigate their risk further by deploying familiar and tested Cisco UCS technology.

**Main Components**

A Cisco HyperFlex cluster can consist of three to eight nodes that are similarly configured, except in a mixed configuration that includes blades and hyperconverged nodes. The best practice is to create a highly available cluster with N+1 resiliency, in which the cluster can sustain all virtual machines with one node in maintenance mode or in a failed state. This solution requires a minimum of four converged nodes per cluster. Converged nodes have processing, cache, and capacity layers together in a unit such as a Cisco HyperFlex HX220c M4 Node.

Each node has a 120-GB solid-state disk (SSD) drive, used for Cisco HyperFlex HX Data Platform housekeeping and logs, and a larger 480-GB high-endurance SSD drive, used for write logs and for caching read and write data. Storage capacity is provided by a set of six 1.2-terabyte (TB) 10,000-rpm 12-Gbps SAS hard disk drives (HDDs). Cisco HyperFlex HX-Series nodes are managed by Cisco UCS Manager hosted in a pair of fault-tolerant, low-latency Cisco UCS fabric interconnects.

The network layer can be any pair of switches with 10-Gbps bandwidth. In this case, a pair of Cisco Nexus 9372 platform switches in standalone mode is used for connectivity to the existing network. The hypervisor used is VMware ESXi 6.0 U1.
Table 1 lists the main components used in a Cisco HyperFlex cluster and the versions tested.

**Table 1. Main Components of Cisco HyperFlex Cluster**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Device</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing</td>
<td>Cisco HyperFlex HX220c M4 Node</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco UCS 6248UP 48-Port Fabric Interconnect</td>
<td>Release 2.2(6f)</td>
</tr>
<tr>
<td>Network</td>
<td>Cisco Nexus 9372 platform switch</td>
<td>Release 6.1(2)I3(1)</td>
</tr>
<tr>
<td>Storage</td>
<td>SSD: 1 x 120 GB and 1 x 480 GB SSD drives</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HDD: 6 x 1.2-TB HDDs</td>
<td></td>
</tr>
<tr>
<td>Software</td>
<td>VMware vSphere ESXi</td>
<td>Release 6.0 U1</td>
</tr>
<tr>
<td></td>
<td>VMware vCenter</td>
<td>Release 6.0 U1</td>
</tr>
<tr>
<td></td>
<td>Cisco HyperFlex HX Data Platform</td>
<td>Release 1.7.1</td>
</tr>
</tbody>
</table>

The description of the solution architecture provides more details about how these components are integrated to form the Cisco HyperFlex HX Data Platform.

**Introduction**

The Cisco HyperFlex solution provides a simple and precisely controlled approach to integrating widely available processing nodes, such as rack and blade servers, in a platform with resiliency and scalable performance. This software-defined approach results in the creation of a flexible, agile, and efficient infrastructure. Capacity can more closely keep pace with demand at lower cost than with integrated infrastructure because of the greater precision with which the building blocks can be deployed and managed.

The solution includes the essential features of resiliency and data retention and improves efficiency through capabilities such as data deduplication and compression.

The Cisco HyperFlex HX Data Platform serves a single shared pool of computing, networking, and storage resources from separate nodes for consumption by a mix of workloads. It is managed by Cisco UCS Manager, increasing operational efficiency with a single pane for firmware and console management. The HX Data Platform is managed from the familiar VMware vCenter management console through a plug-in.

**Cisco HyperFlex HX-Series Hardware**

The Cisco HyperFlex HX220c M4 Node is an essential component in the design of Cisco HyperFlex software-defined infrastructure. It combines the Cisco UCS C220 M4 Rack Server with the SDS functions of the Cisco HyperFlex HX Data Platform. Cisco HyperFlex HX-Series nodes are then integrated into a converged fabric by connecting to a pair of Cisco UCS 6248UP fabric interconnects. Cisco UCS Manager, hosted in the fabric interconnects, is used to manage all hardware in the cluster from a single console.

Important innovations in the platform include a standards-based unified network fabric, Cisco virtualized interface card (VIC) support, and Cisco Extended Memory technology. The system uses a single-connect architecture, which eliminates the need for multiple Ethernet connections from each node in the cluster. Thus, cluster expansion is simplified, resulting in quicker deployment and fewer errors.

**Cisco Nexus 9000 Series Switches**

The solution requires a redundant set of low-latency, 10-Gbps switches for connection to shared services such as Microsoft Active Directory, Domain Name System (DNS), Network Time Protocol (NTP), Dynamic Host
Configuration Protocol (DHCP), and VMware vCenter. The switches used for this purpose are a pair of Cisco Nexus 9372PX Switches operating in standalone mode.

The Cisco Nexus 9372PX and 9372PX-E Switches provide a line-rate Layer 2 and Layer 3 feature set in a compact form factor. Each switch offers a flexible switching platform for both three-tier and spine-and-leaf architectures as a leaf node. With the option to operate in either NX-OS mode (for Cisco NX-OS Software) or ACI mode (for Cisco Application Centric Infrastructure [Cisco ACI™]), these switches can be deployed in small business, enterprise, and service provider environments.

The Cisco Nexus 9372PX and 9372PX-E Switches have forty-eight 1- and 10-Gbps Enhanced Small Form Pluggable (SFP+) ports and six Quad SFP+ (QSFP+) uplink ports. All the ports are line rate, delivering 1.44 terabits per second (Tbps) of throughput in a 1-rack-unit (1RU) form factor.

To provide investment protection, a Cisco 40-Gbps bidirectional transceiver allows reuse of an existing 10 Gigabit Ethernet multimode cable plant for 40 Gigabit Ethernet. The solution also supports 1- and 10-Gbps access connectivity for data centers that are migrating access switching infrastructure to faster speeds.

Storage
Physical storage in Cisco HyperFlex Systems is provided by individual hyperconverged nodes in the cluster. A converged node provides computing and memory resources, an SSD-based cache layer for staging read and write operations, and a capacity layer that includes varying numbers of spinning media (HDDs) for persistent storage.

Cisco HyperFlex software consolidates isolated pockets of storage from individual converged nodes into a log-structured file system called the Cisco HyperFlex HX Data Platform. The log-structured file system assembles blocks to be written to the cache until a configurable write log is full or until workload conditions dictate that it be destaged to a spinning disk. When existing data is (logically) overwritten, the log-structured approach appends a new block and updates the metadata. When the cache is destaged, the write operation consists of a single disk seek operation with a large amount of data written. This approach improves performance significantly compared to the traditional read-modify-write model, which is characterized by numerous seek operations and small amounts of data written at a time.

Data blocks written to disk are compressed into objects and sequentially laid out in fixed-size segments. The objects are distributed across all nodes in the cluster to make uniform use of storage capacity. By using a sequential layout, the platform helps increase flash-memory endurance and makes the best use of the read and write performance characteristics of HDDs, which are well suited for sequential I/O. The platform includes enterprise features such as thin provisioning, space-efficient clones, and snapshots for data protection. Inline deduplication and compression are turned on by default and contribute to significant increases in resource utilization.

The log-structured file system efficiently writes to the persistent tier by appending to the file system after compression. Native Cisco HyperFlex HX Data Platform snapshots, have low overhead and, unlike competitive solutions, do not suffer performance penalties as additional snapshots are created or deleted.

VMware vSphere
VMware vSphere provides a common virtualization layer (the hypervisor) for a computer’s physical resources: the VMware ESX host. The hypervisor allows provisioning of precisely controlled and fully functional virtual machines with the required CPU, memory, disk, and network connectivity characteristics. Virtual machines can run the operating system and application workload of choice in an isolated manner for increased utilization of the underlying hardware.
The high-availability features of VMware vSphere 6.0 that are relevant to this solution include the following:

- **VMware vMotion**: Provides live migration of virtual machines within a virtual infrastructure cluster, with no virtual machine downtime or service disruption
- **VMware Storage vMotion**: Provides live migration of virtual machine disk (vmdk) files between data stores whether within or across storage arrays, with no virtual machine downtime or service disruption
- **VMware vSphere High Availability**: Detects and provides rapid recovery for a failed virtual machine in a cluster
- **VMware Distributed Resource Scheduler (DRS)**: Provides load balancing of computing capacity in a cluster

VMware vCenter Server provides a scalable and extensible platform that forms the foundation for virtualization management for the vSphere cluster. vCenter manages all vSphere hosts and their virtual machines.

**Cisco HyperFlex HX Data Platform**

In a Cisco HyperFlex System, the data platform requires a minimum of three Cisco HyperFlex HX-Series converged nodes for the default three-way mirroring of data. To create a highly available cluster with N+1 resiliency, the solution considers a minimum of four hyperconverged nodes per cluster. Each node includes a Cisco HyperFlex HX Data Platform controller that implements the distributed file system using internal flash-based SSD drives and high-capacity HDDs to store data. The controllers communicate with each other over 10 Gigabit Ethernet to present a single pool of storage that spans the nodes in the cluster. Individual nodes access data through a data layer using file, block, object, or API plug-ins. As nodes are added, the cluster scales to deliver computing, storage capacity, and I/O performance.

In the VMware vSphere environment, the controller occupies a virtual machine with a dedicated number of processor cores and memory, allowing it to deliver consistent performance and not affect the performance of the other virtual machines in the cluster. The controller can access all storage resources without hypervisor intervention through the VMware VMDirectPath feature. It uses the node's memory and SSD drives as part of a distributed caching layer, and it uses the node's HDDs for distributed capacity storage. The controller integrates the data platform into VMware software through the use of two preinstalled VMware ESXi vSphere Installation Bundles (VIBs):

- **IO Visor**: This scvmclient VIB provides a network file system (NFS) mount point so that the ESXi hypervisor can access the virtual disk drives that are attached to individual virtual machines. From the hypervisor's perspective, it is simply attached to a network file system.
- **vStorage API for Array Integration (VAAI)**: This storage offload API mechanism is used by vSphere to request advanced file system operations related to snapshots and cloning from the underlying storage subsystem. The controller causes these operations to occur by manipulating the metadata rather than actually copying data, providing rapid response and thus rapid deployment of new application environments.
As shown in Figure 1, the IO Visor intercepts workload traffic and stripes the block across available nodes in the cluster. The data then bypasses the hypervisor using VMDirectPath and is cached on the larger cache disk in one of the dedicated partitions. Replication across nodes takes place at this layer. Write blocks continue to be written to write logs until they are full, at which time they are marked as passive and destaged to disk. Data optimization processes such as deduplication and compression occur when the data is destaged from the cache and before it is written to disks.

The data platform implements a log-structured file system that uses a caching layer in the SSDs to accelerate read requests and write responses, and a persistence layer implemented with HDDs for capacity. The log-structured layer replicates incoming data to one or more SSDs located in different nodes before the write operation is acknowledged to the application. This process allows incoming write operations to be acknowledged quickly while protecting data from SSD or node failures. If an SSD or node fails, the replica is quickly re-created on other SSDs or nodes using the available copies of the data.

The distributed object layer also replicates data that is moved from the write cache to the capacity layer. This replicated data is likewise protected from hard-disk or node failures. A total of three data copies are available, enabling you to survive disk or node failures without risk of data loss. See the Cisco HyperFlex HX Data Platform system administration guide for a complete list of fault-tolerant configurations and settings.
Citrix XenDesktop 7.8 and Citrix Provisioning Services 7.8

Citrix XenApp and XenDesktop 7.8

Citrix XenApp and XenDesktop are application and desktop virtualization solutions built on a unified architecture so they're simple to manage and flexible enough to meet the needs of all your organization's users. XenApp and XenDesktop have a common set of management tools that simplify and automate IT tasks. You use the same architecture and management tools to manage public, private, and hybrid cloud deployments as you do for on-premises deployments.

Citrix XenApp delivers the following:

- XenApp published apps, also known as server-based hosted applications: These are applications hosted from Microsoft Windows servers to any type of device, including Windows PCs, Macs, smartphones, and tablets. Some XenApp editions include technologies that further optimize the experience of using Windows applications on a mobile device by automatically translating native mobile-device display, navigation, and controls to Windows applications; enhancing performance over mobile networks; and enabling developers to optimize any custom Windows application for any mobile environment.
- XenApp published desktops, also known as server-hosted desktops: These are inexpensive, locked-down Windows virtual desktops hosted from Windows server operating systems. They are well suited for users, such as call center employees, who perform a standard set of tasks.
- Virtual machine–hosted applications: These are applications hosted from machines running Windows desktop operating systems that can’t be hosted in a server environment.
- Windows applications delivered with Microsoft App-V: These applications use the same management tools that you use for the rest of your XenApp deployment.
- Citrix XenDesktop 7.8: This solution includes significant enhancements to help customers deliver Windows applications and desktops as mobile services while addressing management complexity and associated costs. Enhancements in this release include:
  - Unified product architecture for XenApp and XenDesktop: The FlexCast Management Architecture (FMA). This release supplies a single set of administrative interfaces to deliver both hosted-shared applications (RDS) and complete virtual desktops (VDI). Unlike earlier releases that separately provisioned Citrix XenApp and XenDesktop farms, the XenDesktop 7.8 release allows administrators to deploy a single infrastructure and use a consistent set of tools to manage mixed application and desktop workloads.
  - Support for extending deployments to the cloud: This release supports hybrid-cloud provisioning from Microsoft Azure, Amazon Web Services (AWS), or any cloud-platform-powered public or private cloud. Cloud deployments are configured, managed, and monitored through the same administrative consoles as deployments on traditional on-premises infrastructure.

Citrix XenDesktop delivers:

- **VDI desktops**: These virtual desktops each run a Microsoft Windows desktop operating system rather than running in a shared, server-based environment. They can provide users with their own desktops that they can fully personalize.
- **Hosted physical desktops**: This solution is well suited for providing secure access to powerful physical machines, such as blade servers, from within your data center.
- **Remote PC access:** This solution allows users to log in to their physical Windows PC from anywhere over a secure XenDesktop connection.

- **Server VDI:** This solution is designed to provide hosted desktops in multitenant cloud environments.

- **Capabilities that allow users to continue to use their virtual desktops:** These capabilities let users continue to work while not connected to your network.

In the tests reported in this document, Citrix XenDesktop was deployed on the Cisco HyperFlex platform (Figure 2).

**Figure 2.** Logical Architecture of Citrix XenDesktop

**Citrix Provisioning Services 7.8**

Most enterprises struggle to keep up with the proliferation and management of computers in their environments. Each computer, whether it is a desktop PC, a server in a data center, or a kiosk-type device, must be managed as an individual entity. The benefits of distributed processing come at the cost of distributed management. It costs time and money to set up, update, support, and ultimately decommission each computer. The initial cost of the machine is often dwarfed by operating costs.

Citrix PVS takes a very different approach from traditional imaging solutions by fundamentally changing the relationship between hardware and the software that runs on it. By streaming a single shared disk image (virtual disk [vDisk]) rather than copying images to individual machines, PVS enables organizations to reduce the number of disk images that they manage, even as the number of machines continues to grow, simultaneously providing the efficiency of centralized management and the benefits of distributed processing.
In addition, because machines are streaming disk data dynamically and in real time from a single shared image, machine image consistency is essentially ensured. At the same time, the configuration, applications, and even the OS of large pools of machines can be completed changed in the time it takes the machines to reboot.

Using PVS, any vDisk can be configured in standard-image mode. A vDisk in standard-image mode allows many computers to boot from it simultaneously, greatly reducing the number of images that must be maintained and the amount of storage space that is required. The vDisk is in read-only format, and target devices cannot change the image.

Benefits for Citrix XenApp and Other Server Farm Administrators
If you manage a pool of servers that work as a farm, such as Citrix XenApp servers or web servers, maintaining a uniform patch level on your servers can be difficult and time consuming. With traditional imaging solutions, you start with a clean golden master image, but as soon as a server is built with the master image, you must patch that individual server along with all the other individual servers. Rolling out patches to individual servers in your farm is not only inefficient, but the results can be unreliable. Patches often fail on an individual server, and you may not know that you have a problem until users start complaining or the server experiences an outage. After that happens, getting the server resynchronized with the rest of the farm can be challenging, and sometimes a full reimaging of the machine is required.

With Citrix PVS, patch management for server farms is simple and reliable. You start by managing your golden image, and you continue to manage that single golden image. All patching is performed in one place and then streamed to your servers when they boot. Server build consistency is assured because all your servers use a single shared copy of the disk image. If a server becomes corrupted, simply reboot it, and it is instantly restored to the known good state of your master image. Upgrades are extremely fast to implement. After you have your updated image ready for production, you simply assign the new image version to the servers and reboot them. You can deploy the new image to any number of servers in the time it takes them to reboot. Just as important, rollback can be performed in the same way, so problems with new images do not need to take your servers or your users out of commission for an extended period of time.

Benefits for Desktop Administrators
Because Citrix PVS is part of Citrix XenDesktop, desktop administrators can use PVS’s streaming technology to simplify, consolidate, and reduce the costs of both physical and virtual desktop delivery. Many organizations are beginning to explore desktop virtualization. Although virtualization addresses many of IT’s needs for consolidation and simplified management, deploying it also requires deployment of supporting infrastructure. Without PVS, storage costs can make desktop virtualization too costly for the IT budget. However, with PVS, IT can reduce the amount of storage space required for VDI by up to 90 percent. And with a single image to manage instead of hundreds or thousands of desktops, PVS significantly reduces the cost, effort, and complexity of desktop administration.

Different types of workers across the enterprise need different types of desktops. Some require simplicity and standardization, and others require high performance and personalization. XenDesktop can meet these requirements in a single solution using Citrix FlexCast delivery technology. With FlexCast, IT can deliver every type of virtual desktop, each specifically tailored to meet the performance, security, and flexibility requirements of each individual user.

Not all desktops applications can be supported by virtual desktops. For these scenarios, IT can still reap the benefits of consolidation and single-image management. Desktop images are stored and managed centrally in the data center and streamed to physical desktops on demand. This model works particularly well for standardized
desktops such as those in lab and training environments and call centers and thin-client devices used to access virtual desktops.

Citrix Provisioning Services Solution

Citrix PVS streaming technology allows computers to be provisioned and reprovisioned in real time from a single shared disk image. With this approach, administrators can completely eliminate the need to manage and patch individual systems. Instead, all image management is performed on the master image. The local hard drive of each system can be used for runtime data caching or, in some scenarios, removed from the system entirely, which reduces power use, system failure rate, and security risk.

The PVS solution's infrastructure is based on software-streaming technology. After PVS components are installed and configured, a vDisk is created from a device’s hard drive by taking a snapshot of the OS and application image and then storing that image as a vDisk file on the network. A device used for this process is referred to as a master target device. The devices that use the vDisks are called target devices. vDisks can exist on a PVS or file share, or in larger deployments, on a storage system with which PVS can communicate (Small Computer System Interface over IP [iSCSI], SAN, network-attached storage [NAS], and Common Internet File System [CIFS] solutions). vDisks can be assigned to a single target device in private-image mode, or to multiple target devices in standard-image mode.

Citrix Provisioning Services Infrastructure

The Citrix PVS infrastructure design directly relates to administrative roles within a PVS farm. The PVS administrator role determines which components that administrator can manage or view in the console.

A PVS farm contains several components. Figure 3 provides a high-level view of basic PVS infrastructure and shows how PVS components might appear within that implementation.

Figure 3. Logical Architecture of Citrix Provisioning Services
The following new features are available with Provisioning Services (PVS) 7.8:

- Streaming VHDX formatted disks
- Support for Microsoft Windows 10 Enterprise and Professional editions
- Support for Unified Extensible Firmware Interface (UEFI) enhancements
- The licensing grace period for Provisioning Services has changed from 96 hours to 30 days, for consistency with XenApp and XenDesktop
- Enhancements to API
- vGPU-enabled XenDesktop machines can be provisioned using the Provisioning Services XenDesktop Setup Wizard
- Support for System Center Virtual Machine Manager Generation 2 VMs
- FIPS support
- XenApp Session Recording Enabled by Default

Solution Architecture

Figure 4 shows the cluster topology described in this document.

**Figure 4.** Cluster Topology
Reference Configuration

The hardware platform consists of nodes with dual processors and 384 GB of memory each. The processors are Intel® Xeon® processor E5-2680 v3 CPUs, each with 12 cores and operating at 2.5 GHz. The density and number of memory DIMMs selected are consistent with Intel’s recommendations for optimal performance given the number of memory channels and DIMMs supported by each CPU (Figure 5).

**Figure 5.** Processor Configuration

```
A   A   C
    
B
    C

C   C   C
    
D   D   C

24x 16 GB = 384 GB
```
Hardware and Software Specifications

Table 2 provides cluster-based specifications. It shows the hardware required for a minimum configuration cluster with N+1 resiliency.

Table 2. Cluster-Based Specifications

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperconverged nodes</td>
<td>8 Cisco HyperFlex HX220c M4 Nodes</td>
<td>A cluster can consist of 4 to 8 nodes.</td>
</tr>
<tr>
<td>Fabric interconnects</td>
<td>2 Cisco UCS 6248UP fabric interconnects</td>
<td>Fabric interconnects provide policy-based stateless computing.</td>
</tr>
<tr>
<td>Layer 2 switches</td>
<td>2 Cisco Nexus 9372PX Switches</td>
<td>Optional: Deploy a pair of any 10-Gbps switches for connectivity.</td>
</tr>
</tbody>
</table>

Table 3 provides individual node specifications. It presents component-level details for each node of the cluster used in the tests reported in this document.

Table 3. Individual Node Specifications

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>2 Intel Xeon processor E5-2680 v3 CPUs</td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td>24 x 16-GB DIMMs</td>
<td></td>
</tr>
<tr>
<td>FlexFlash Secure Digital (SD) card</td>
<td>2 x 64-GB SD cards</td>
<td>Boot drives</td>
</tr>
<tr>
<td>SSD</td>
<td>1 x 120-GB SSD</td>
<td>Configured for housekeeping tasks</td>
</tr>
<tr>
<td></td>
<td>1 x 480 GB SSD</td>
<td>Configured as cache</td>
</tr>
<tr>
<td>HDD</td>
<td>6 x 1.2-TB 10,000-rpm 12-Gbps SAS drives</td>
<td>Capacity disks for each node</td>
</tr>
<tr>
<td>Hypervisor</td>
<td>VMware vSphere 6.0 U1B</td>
<td>Virtual platform for SDS</td>
</tr>
<tr>
<td>Cisco HyperFlex HX Data Platform</td>
<td>Cisco HyperFlex HX Data Platform Release 1.7.1</td>
<td></td>
</tr>
</tbody>
</table>

You can use the VMware vCenter web client to obtain an enterprise-wide view. You can set up each vCenter server instance to manage multiple Cisco HyperFlex HX-Series clusters to scale with separation across clusters for greater security. You can also then extend this model by connecting multiple instances of vCenter servers using vCenter linked mode if desired. Linking multiple vCenter instances allows you to view and search resources across all instances (Figure 6).
Table 4 shows a device-level mapping between the Cisco HyperFlex components and the underlying node hardware.

**Table 4. Device-Level Mapping**

<table>
<thead>
<tr>
<th>Component Function</th>
<th>Cisco HyperFlex HX220c Device</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boot (ESXi)</td>
<td>FlexFlash SD cards 1 and 2</td>
<td>SD card 1 mirrored to SD card 2</td>
</tr>
<tr>
<td>Control virtual machine bootstrap</td>
<td>FlexFlash SD cards 1 and 2</td>
<td>SD card 1 mirrored to SD card 2</td>
</tr>
<tr>
<td>Control virtual machine housekeeping, data,</td>
<td>SSD 1 in front-slot 1 (120 GB)</td>
<td>/var/log, /var/core, and /zookeeper (housekeeping)</td>
</tr>
<tr>
<td>and logs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cache layer</td>
<td>SSD 2 in front-slot 2 (480 GB)</td>
<td>Intel 3610-based high-endurance SSD for caching</td>
</tr>
<tr>
<td>Capacity layer</td>
<td>6 x 1.2-TB HDDs in slots 3 to 8</td>
<td>10,000-rpm 12-Gbps SAS HDDs</td>
</tr>
</tbody>
</table>
Network Layout

Figure 7 shows a virtual network interface card (vNIC), which is a virtual machine NIC (vmnic), and virtual switch (vSwitch) setup for networking. The goal is to provide redundant vNICs for each vSwitch and to provide parallel paths with sufficient bandwidth and separation to prevent congestion from affecting performance. Four VLANs are created: for management (routable subnet), NFS storage (jumbo frames), production workload traffic, and VMware vMotion (jumbo traffic).

Figure 7. Network Layout
Figure 8 shows the configuration for this design.

**Figure 8. Networking Configuration**

Quality-of-Service Setup in Cisco UCS Manager

Quality of service (QoS) refers to the capability of a network to provide better service to selected network traffic. The primary goal of QoS is to provide priority for specific traffic, including dedicated bandwidth and latency and improved loss characteristics. In configuring QoS, you also need to help ensure that prioritizing one type of traffic flow does not make other flows fail.

Some of the four subnets used in this design require larger frames, or jumbo frames, which are any frames with a payload of more than 1500 bytes. For the fabric interconnects to pass along these jumbo frames, the appropriate priority needs to be set in the QoS system class section in Cisco UCS Manager. Table 5 shows the settings: priority, class of service (CoS), maximum transmission unit (MTU), etc.
Table 5. QoS Settings

<table>
<thead>
<tr>
<th>Priority</th>
<th>Enabled</th>
<th>CoS</th>
<th>Packet Drop</th>
<th>Weight</th>
<th>MTU</th>
<th>Multicast Optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum</td>
<td>Yes</td>
<td>5</td>
<td>No</td>
<td>4</td>
<td>9216</td>
<td>No</td>
</tr>
<tr>
<td>Gold</td>
<td>Yes</td>
<td>4</td>
<td>Yes</td>
<td>4</td>
<td>Normal</td>
<td>Yes</td>
</tr>
<tr>
<td>Silver</td>
<td>Yes</td>
<td>2</td>
<td>Yes</td>
<td>Best effort</td>
<td>Normal</td>
<td>Yes</td>
</tr>
<tr>
<td>Bronze</td>
<td>Yes</td>
<td>1</td>
<td>Yes</td>
<td>Best effort</td>
<td>9216</td>
<td>No</td>
</tr>
<tr>
<td>Best Effort</td>
<td>Yes</td>
<td>Any</td>
<td>Yes</td>
<td>Best effort</td>
<td>Normal</td>
<td>No</td>
</tr>
<tr>
<td>Fibre Channel</td>
<td>Yes</td>
<td>3</td>
<td>No</td>
<td>Best effort</td>
<td>Fibre Channel</td>
<td>–</td>
</tr>
</tbody>
</table>

The QoS policy associates vNIC templates with the appropriate QoS priority (Table 6).

Table 6. QoS Policy Settings

<table>
<thead>
<tr>
<th>QoS Policy Name</th>
<th>QoS Class</th>
<th>Burst Size</th>
<th>Rate</th>
<th>Host Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum</td>
<td>Platinum</td>
<td>10,240</td>
<td>Line rate</td>
<td>None</td>
</tr>
<tr>
<td>Gold</td>
<td>Gold</td>
<td>10,240</td>
<td>Line rate</td>
<td>None</td>
</tr>
<tr>
<td>Silver</td>
<td>Silver</td>
<td>10,240</td>
<td>Line rate</td>
<td>None</td>
</tr>
<tr>
<td>Bronze</td>
<td>Bronze</td>
<td>10,240</td>
<td>Line rate</td>
<td>None</td>
</tr>
<tr>
<td>Best Effort</td>
<td>Best Effort</td>
<td>10,240</td>
<td>Line rate</td>
<td>None</td>
</tr>
</tbody>
</table>

The final step is to edit the vNIC template with the QoS policy and adjust the MTU size (Table 7).

Table 7. vNIC Template Settings

<table>
<thead>
<tr>
<th>vNIC Template Name</th>
<th>MAC Address Pool</th>
<th>Fabric</th>
<th>MTU</th>
<th>QoS Policy</th>
<th>Other Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>mgmt-a</td>
<td>mgmt-a</td>
<td>A</td>
<td>1500</td>
<td>Silver</td>
<td>Network control policy: hyperflex-infra</td>
</tr>
<tr>
<td>mgmt-b</td>
<td>mgmt-b</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>storage-a</td>
<td>storage-a</td>
<td>A</td>
<td>9000</td>
<td>Gold</td>
<td>Network control policy: hyperflex-infra</td>
</tr>
<tr>
<td>storage-b</td>
<td>storage-b</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vm-network-a</td>
<td>vm-network-a</td>
<td>A</td>
<td>1500</td>
<td>Platinum</td>
<td>Network control policy: hyperflex-vm</td>
</tr>
<tr>
<td>vm-network-b</td>
<td>vm-network-b</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vmotion-a</td>
<td>vmotion-a</td>
<td>A</td>
<td>9000</td>
<td>Bronze</td>
<td>Network control policy: hyperflex-infra</td>
</tr>
<tr>
<td>vmotion-b</td>
<td>vmotion-b</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Make similar changes to the corresponding vNIC settings in VMware vCenter.
Network Setup in Cisco UCS Manager

Figure 9 shows the network setup in Cisco UCS Manager.

**Figure 9.** Network Setup in Cisco UCS Manager

Storage Layout

The Cisco HyperFlex HX Data Platform controller handles all read and write requests for volumes that the hypervisor accesses and thus mediates all I/O from the virtual machines. The hypervisor has a dedicated boot disk independent of the data platform.

Incoming data is distributed across all nodes in the cluster to optimize performance using the caching tier. Effective data distribution is achieved by mapping incoming data to stripe units that are stored evenly across all nodes, with the number of data replicas determined by the policies you set. When an application writes data, the data is sent to the appropriate node based on the stripe unit that includes the relevant block of information. This data distribution approach in combination with the capability to have multiple streams writing at the same time helps prevent both network and storage hot spots. It also delivers the same I/O performance regardless of virtual machine location and provides more flexibility in workload placement.

Figure 10 shows the storage layout for the Cisco HyperFlex HX Data Platform.

**Figure 10.** Storage Layout

Cisco HyperFlex HX Data Platform
● **Data write operations:** For write operations, data is written to the local SSD cache and is replicated to the remote SSDs in parallel before the write operation is acknowledged. This approach eliminates the possibility of data loss due to SSD or node failure. The write operations are then staged to inexpensive, high-density HDDs for long-term storage. By using high-performance SSDs with low-cost, high-capacity HDDs, you can optimize the cost of storing and retrieving application data at full speed.

● **Data read operations:** For read operations, data that is local will usually be read directly from the local SSD. If the data is not local, the data is retrieved from an SSD on the remote node. This approach allows the platform to use all SSDs for read operations, eliminating bottlenecks and delivering superior performance. Data recently read from the persistent tier is cached both in SSDs and in memory. Having the most frequently used data stored so close to the virtual machines helps make Cisco HyperFlex Systems perform very well for virtualized applications.

Thus, when you move a virtual machine to a new location, using, for instance, VMware DRS, the HX Data Platform does not require movement of the data. Movement of virtual machines thus has no impact on performance or cost.

Figure 11 shows the Cisco HyperFlex HX Data Platform
Performance Testing

The HX Data Platform decouples the caching tier from the persistence tier and supports independent scaling of I/O performance and storage capacity. This flexibility sets the stage for the introduction of blades as computing-only nodes in a setup in which storage from converged nodes can be consumed. This mixed configuration allows independent scaling, which addresses the problem of stranded capacity.

In the event of a problem in the HX Data Platform controller software, data requests from the applications residing in that node are automatically routed to other controllers in the cluster.

The desktop virtualization performance evaluation of the freshly installed Cisco HyperFlex HX220c M4S 8-node cluster running the general availability Release 1.7.1 software was conducted following the Cisco Virtual Desktop Infrastructure Test Protocol and Success Criteria for Desktop Virtualization using Login VSI 4.1.4. Figure 12 shows the configuration tested.

Cisco HyperFlex Systems with Citrix XenDesktop and Provisioning Services 7.8 Detailed Architecture

- Cisco UCS 6248UP Fabric Interconnect
- 8 Cisco HyperFlex HX220c M4S Rack Servers
- 2 x Intel Xeon Processor ES-2680 v3 CPUs at 2.5 GHz
- 2 x 64-GB SD Card
- 384 GB (24 x 16-GB DDR4) of RAM
- 1 x Cisco UCS VIC 1227 Modular LAN on Motherboard (mLOM)
- 1 x Cisco 12-Gbps Modular SAS Host Bus Adapter (HBA)
- 1 x 120-GB Intel SATA Enterprise Value SSD Drive
- 1 x 480-GB Intel SATA Enterprise Value SSD for Cache
- 6 x 1.2-TB 2.5-Inch Seagate 10,000-rpm SAS HHDs for Capacity
The Cisco HyperFlex System runs in a cluster on VMware ESXi 6.0 U1Bb managed by the Cisco HyperFlex plug-in to the VMware vCenter web client. A 1000-seat Citrix XenDesktop 7.8 provisioned by Citrix PVS was used in each test case.

This fresh-installation testing used three test cases running the Login VSI 4.1.4.2 knowledge worker workload in benchmark mode:

- 48-minute Login VSI knowledge worker test in benchmark mode (end-user experience during login storm)
- 8-hour Login VSI knowledge worker test in benchmark mode (workday stability in steady state)

The tests monitored performance statistics during a virtual desktop boot storm and then waited for the systems to settle for about 20 minutes. Testing tracked ramp-up, which is the login interval for all 1000 sessions; steady state, in which all sessions are logged on and active; and logoff.

48-Minute Standard Benchmark Mode Test Results
Login VSI tests were run on 1000 XenDesktop pooled Windows 7 virtual machines hosted on eight Cisco HyperFlex HX220c M4S servers with exceptional user performance as represented by the Login VSI Analyzer score and latency values (Figures 13 through 19).

Test result highlights include:

- 0.7 second baseline response time
- 1 second average response time with 1000 desktops running
- 2 second maximum response time with 1000 desktops running
- Average CPU utilization of 80 percent
- Average of 300 GB of RAM used (384 GB available)
- Average network utilization of 141 MBps per cluster
- Average of 1.9 milliseconds (ms) of I/O latency per cluster
- 11,900 peak I/O operations per second (IOPS) per cluster at steady state
- 210 Mbps peak throughput per cluster at steady state

Figure 13. Login VSI Analyzer Chart for 1000 Sessions with End-User Experience (EUX) Response Time

Figure 14. Host CPU Utilization from VMware ESXTOP: 1000 Pooled Desktops, Average CPU Utilization as a Percentage
Figure 15. Host Memory Use from VMware ESXTOP: 1000 Pooled Desktops, Average Memory Use in MB

Figure 16. Host Network Utilization from VMware ESXTOP: 1000 Pooled Desktops, Average Network Utilization in Mbps
**Figure 17.** Host Storage Latency from VMware ESXTOP: 1000 Pooled Desktops, Average IOPS

**Figure 18.** Host Storage Read-Write Rate from VMware ESXTOP: 1000 Pooled Desktops, Average Read-Write Rate in MBps
Figure 19.  Performance Statistics from Cisco HyperFlex Web User Interface (WebUI): 1000 Pooled Desktops

8-Hour Benchmark Mode Test Results
Login VSI tests were run on 1000 pooled desktops hosted on eight Cisco HyperFlex HX220c M4S servers with exceptional user performance as represented by the Login VSI Analyzer score and latency values (Figures 20 through 26).

Test result highlights include:

- 0.7 second baseline response time
- 1 second average response time with 1000 desktops running
- 2.7 second maximum response time with 1000 desktops running
- Average CPU utilization of 80 percent
- Average of 300 GB of RAM used out of 384 GB available
- Average network utilization of 141 MBps per cluster
- Average of 2.5 milliseconds (ms) of I/O latency per cluster
- 10,700 peak I/O operations per cluster (IOPS) at steady state
- 185 Mbps peak throughput per cluster at steady state
**Figure 20.** Login VSI Analyzer Chart for 1000 Sessions with EUX Response Time

**Figure 21.** Host CPU Utilization from VMware ESXTOP: 1000 Pooled Desktops, Average CPU Utilization as a Percentage
Figure 22. Host Memory Use from VMware ESXTOP: 1000 Pooled Desktops, Average Memory Use in MB

![Graph showing host memory use from VMware ESXTOP.]

Figure 23. Host Network Utilization from VMware ESXTOP: 1000 Pooled Desktops, Average Network Utilization in Mbps

![Graph showing host network utilization from VMware ESXTOP.]

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Figure 24. Host Storage Latency from VMware ESXTOP: 1000 Pooled Desktops, Average IOPS

Figure 25. Host Storage Read-Write Rate from VMware ESXTOP: 1000 Pooled Desktops, Average Read-Write Rate in MBps
Figure 26. Performance Statistics from Cisco HyperFlex WebUI: 1000 Pooled Desktops

Note: As the file system ages, your performance results may vary.
System Sizing

The reference architecture uses the sizing specifications described in this section.

Virtual Machine Test Image Build

Table 8 summarizes the virtual machine image used to provision desktop sessions in the Citrix XenDesktop environment for pooled desktops. The image conformed to testing tool standards and was optimized in accordance with the Citrix PVS optimization wizard that is built into the PVS imaging tool.

The reference architecture and performance tests presented in this document were run on Windows 7 optimized using the PVS optimization wizard.

Table 8. Virtual Machine Image Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Pooled Desktops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop operating system</td>
<td>Microsoft Windows 7 Enterprise SP1 (32-bit)</td>
</tr>
<tr>
<td>Hardware</td>
<td>VMware Virtual Hardware Version 11</td>
</tr>
<tr>
<td>vCPU</td>
<td>2</td>
</tr>
<tr>
<td>Memory</td>
<td>2048 MB</td>
</tr>
<tr>
<td>Memory reserved</td>
<td>2048 MB</td>
</tr>
<tr>
<td>Video RAM</td>
<td>35 MB</td>
</tr>
<tr>
<td>3D graphics</td>
<td>Off</td>
</tr>
<tr>
<td>NIC</td>
<td>1</td>
</tr>
<tr>
<td>Virtual network adapter 1</td>
<td>VMXNet3 adapter</td>
</tr>
<tr>
<td>Virtual SCSI controller 0</td>
<td>LSI</td>
</tr>
<tr>
<td>Virtual disk: VMDK 1</td>
<td>6 GB</td>
</tr>
<tr>
<td>Virtual floppy drive 1</td>
<td>Removed</td>
</tr>
<tr>
<td>Virtual CD/DVD drive 1</td>
<td>Passthrough IDE</td>
</tr>
<tr>
<td>Applications</td>
<td>• Login VSI 4.1.4 application installation</td>
</tr>
<tr>
<td></td>
<td>• Adobe Acrobat 11</td>
</tr>
<tr>
<td></td>
<td>• Adobe Flash Player 16</td>
</tr>
<tr>
<td></td>
<td>• Doro PDF 1.82</td>
</tr>
<tr>
<td></td>
<td>• FreeMind</td>
</tr>
<tr>
<td></td>
<td>• Microsoft Internet Explorer 11</td>
</tr>
<tr>
<td></td>
<td>• Microsoft Office 2010</td>
</tr>
<tr>
<td>VMware tools</td>
<td>Release 10.0.0.3000743</td>
</tr>
<tr>
<td>Citrix Virtual Delivery Agent (VDA)</td>
<td>Version 7.8</td>
</tr>
<tr>
<td>Citrix PVS Agent</td>
<td>Version 7.8</td>
</tr>
</tbody>
</table>
Deduplication and Compression Features

You can use deduplication and compression to improve storage efficiency (Figure 27).

Figure 27. Deduplication and Compression Features

Intel Broadwell Support for HyperFlex

This section describes changes to our solution platform of eight Cisco HyperFlex™ HX220c M4 Nodes with the introduction of the Intel Xeon E5-2600 v4 “Broadwell” processors. This update is not intended to be a comprehensive guide to every aspect of this solution. It provides guidelines for design and sizing to help you build solution platforms for up to 1000 Citrix XenDesktop virtual desktops.

Cisco HyperFlex release 1.7.1-14835 and Cisco UCS Manager 2.2.7 adds support for B200 M4, C220 M4 and C240 M4 blade and rack server to configure with the Intel® Xeon® Processor E5-2600 v4 series CPUs and 2400MHz memory on 6200 Series fabric interconnects.

New Hardware Features in Release 1.7.1-14835

Release 1.7.1-14835 has Installer only changes to support the following:

- Cisco UCS C220 M4, C240 M4, and B200 M4 (compute-only nodes) shipping with the Intel Xeon Processor E5-2600 v4 series (Broadwell) CPUs on Cisco UCS 6200 Series fabric interconnects.
- NVIDIA Tesla M6 GPU accelerator for B200 M4 (compute-only) servers
- NVIDIA Tesla M60 GPU accelerator for C-Series Servers
New Software Features in Release 1.7.1-14835

HX Data Platform Installer is compatible with Cisco UCS Manager 2.2(7c)

- HX Data Platform: Please note these are HX Installer only changes HX Data Platform software version remains at 1.7.1 and existing customers do not need to upgrade the HX Data Platform.
- UCS Manager: Existing customers would need to upgrade to UCS Manager 2.2(7c). Please see HyperFlex Getting Started Guide for more details on upgrade steps.

Dependencies

Table 9 shows interdependencies between the hardware and versions of Cisco HX Data Platform.

<table>
<thead>
<tr>
<th>Component</th>
<th>UCS Manager version</th>
<th>HX Data Platform Installer Version</th>
<th>HX Data Platform Software Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel v4 Broadwell CPU</td>
<td>2.2(7c)</td>
<td>1.7.3</td>
<td>1.7.3</td>
</tr>
<tr>
<td>Intel v4 Broadwell CPU</td>
<td>2.2(7c)</td>
<td>1.7.1-14835</td>
<td>1.7.1</td>
</tr>
</tbody>
</table>

Table 10 shows components and their software version configured for the reference architecture in study.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Device</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing</td>
<td>Cisco HyperFlex HX220c M4 Node</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Cisco UCS 6248UP 48-Port Fabric Interconnect</td>
<td>Release 2.2(7e)</td>
</tr>
<tr>
<td>Network</td>
<td>Cisco Nexus 9372 platform switch</td>
<td>Release 6.1(2)I3(1)</td>
</tr>
<tr>
<td>Storage</td>
<td>SSD: 1 x 120 GB and 1 x 480 GB SSD drives</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>HDD: 6 x 1.2-TB HDDs</td>
<td>–</td>
</tr>
<tr>
<td>Software</td>
<td>VMware vSphere ESXi</td>
<td>Release 6.0 U1B</td>
</tr>
<tr>
<td></td>
<td>VMware vCenter</td>
<td>Release 6.0 U1B</td>
</tr>
<tr>
<td></td>
<td>Cisco HyperFlex HX Data Platform</td>
<td>Release 1.7.1-14835</td>
</tr>
</tbody>
</table>

Reference Configuration Update

The desktop virtualization performance evaluation of the Cisco HyperFlex HX220c M4S 8-node cluster running the general availability Release 1.7.1 software was conducted following the Cisco Virtual Desktop Infrastructure Test Protocol and Success Criteria for Desktop Virtualization using Login VSI 4.1.4.

One 1000-seat Citrix XenDesktop 7.8 environment was provisioned by Citrix Provisioning Server and a second 1000-seat Citrix XenDesktop 7.8 environment was provisioned by Citrix Machine Creation Services (MCS.) Both environments were tested, running Microsoft Windows 10 and Microsoft Office 2016 in each test case.

Customers using Microsoft Windows 7 Enterprise SP1 (32-bit) with Microsoft Office 2010 (32-bit) desktops provisioned by Citrix Provisioning Services should expect approximately 30% higher density on the Broadwell architecture, up to 1296 desktops vs 1000 for the Haswell architecture covered earlier in this document.

This testing used the Login VSI 4.1.4.2 knowledge worker workload in benchmark mode:

- 48-minute Login VSI knowledge worker test in benchmark mode (end-user experience during login storm)
The testing monitored performance statistics during a virtual desktop boot storm and then waited for the systems to settle for about 20 minutes. Testing tracked ramp-up, which is the login interval for all 1000 sessions, steady state, in which all sessions are logged on and active and logoff.

**Hardware Update**

The hardware platform consists of nodes with dual processors and 512 GB of memory each. The processors are Intel® Xeon® processor E5-2690 v4 CPUs, each with 14 cores and operating at 2.6 GHz. The density and number of memory DIMMs selected are consistent with Intel’s recommendations for optimal performance given the number of memory channels and DIMMs supported by each CPU (Figure 28).

**Figure 28.** Processor Configuration

![Processor Configuration Diagram]

**Software Update**

Cisco UCS Manager 2.2(7c)

UCS was upgraded to Release 2.2(7c). This release enables support for the Intel Xeon E5-2600 v4 "Broadwell" processors on the Hx220 M4, Hx240 M4 and "Compute-Only" B200 M4 server platforms and delivers operational and performance enhancements with new peripherals.
Cisco HyperFlex release 1.7.1-14835
Release 1.7.1-14835 has Installer only changes to support the compatibility with Cisco UCS Manager 2.2(7c).

Please note these are HX Installer only changes HX Data Platform software version remains at 1.7.1 and existing customers do not need to upgrade the HX Data Platform.

Performance Testing
The desktop virtualization performance evaluation of the Cisco HyperFlex 1.7.1 running on eight node HX220c-M4S cluster was conducted following the Cisco Virtual Desktop Infrastructure Test Protocol and Success Criteria for Desktop Virtualization using Login VSI 4.1.5. Figure 28 shows the configuration tested.

48-Minute Standard Benchmark Mode Test Results with PVS
Login VSI tests were run on 1000 PVS streamed desktops on eight Cisco HyperFlex HX220c M4S servers with exceptional user performance as represented by the Login VSI Analyzer score and latency values (Figures 29 through 33).

Test result highlights include:

- 0.7 second baseline response time
- 0.9 second average response time with 1000 desktops running
- 2 second maximum response time with 1000 desktops running
- Average CPU utilization of 75 percent
- Average of 300 GB of RAM used (512 GB available)
- Average network utilization of 218 MBps per cluster
- Average of 2.6 milliseconds (ms) of I/O latency per cluster
- 11900 peak I/O operations per second (IOPS) per cluster at steady state
- 210 Mbps peak throughput per cluster at steady state
Figure 29. Login VSI Analyzer Chart for 1000 Sessions with End-User Experience (EUX) Response Time

Figure 30. Host CPU Utilization from VMware ESXTOP: 1000 Pooled Desktops, Average CPU Utilization as a Percentage
Figure 31. Host Memory Use from VMware ESXTOP: 1000 Pooled Desktops, Average Memory Use in MB

Figure 32. Host Network Utilization from VMware ESXTOP: 1000 Pooled Desktops, Average Network Utilization in Mbps
48-Minute Standard Benchmark Mode Test Results with MCS

Login VSI tests were run on 1000 MCS desktops hosted on eight Cisco HyperFlex HX220c M4S servers with exceptional user performance as represented by the Login VSI Analyzer score and latency values (Figures 34 through 38).

Test result highlights include:

- 0.7 second baseline response time
- 0.9 second average response time with 1000 desktops running
- 1.4 second maximum response time with 1000 desktops running
- Average CPU utilization of 75 percent
- Average of 300 GB of RAM used (384 GB available)
- Average network utilization of 163 MBps per cluster
- Average of 2.2 milliseconds (ms) of I/O latency per cluster
- 38680 peak I/O operations per second (IOPS) per cluster at steady state
- 567 Mbps peak throughput per cluster at steady state
**Figure 34.** Login VSI Analyzer Chart for 1000 Sessions with End-User Experience (EUX) Response Time

![Login VSI Analyzer Chart](image1)

**Figure 35.** Host CPU Utilization from VMware ESXTOP: 1000 Pooled Desktops, Average CPU Utilization as a Percentage

![Host CPU Utilization Graph](image2)
Figure 36. Host Memory Use from VMware ESXTOP: 1000 Pooled Desktops, Average Memory Use in MB

Figure 37. Host Network Utilization from VMware ESXTOP: 1000 Pooled Desktops, Average Network Utilization in Mbps
Microsoft Windows 10 Virtual Machine Test Image Build
Virtual Machine Test Image for use with Provisioning Services

Table 11 summarizes the virtual machine image used to provision desktop sessions in the Citrix XenDesktop environment for Pooled Desktops. The image conformed to testing tool standards and was optimized in accordance with the Citrix Provisioning Services optimization wizard which is built into the Provisioning Services imaging tool.

The reference architecture and performance tests presented in this document were run on Windows 10 optimized using the Citrix Provisioning Services optimization wizard.

Table 11. Virtual PVS Machine Image Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Pooled Desktops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop operating system</td>
<td>Microsoft Windows 10 (64-bit)</td>
</tr>
<tr>
<td>Hardware</td>
<td>VMware Virtual Hardware Version 11</td>
</tr>
<tr>
<td>vCPU</td>
<td>2</td>
</tr>
<tr>
<td>Memory</td>
<td>2048 MB</td>
</tr>
<tr>
<td>Memory reserved</td>
<td>2048 MB</td>
</tr>
<tr>
<td>Video RAM</td>
<td>35 MB</td>
</tr>
<tr>
<td>3D graphics</td>
<td>Off</td>
</tr>
<tr>
<td>NIC</td>
<td>1</td>
</tr>
<tr>
<td>Virtual network adapter 1</td>
<td>VMXNet3 adapter</td>
</tr>
<tr>
<td>Virtual SCSI controller 0</td>
<td>LSI</td>
</tr>
<tr>
<td>Virtual disk: VMDK 1</td>
<td>6 GB</td>
</tr>
<tr>
<td>Virtual floppy drive 1</td>
<td>Removed</td>
</tr>
</tbody>
</table>
Virtual Machine Test Image for use with Machine Creation Services

Table 11 summarizes the virtual machine image used to provision desktop sessions in the Citrix XenDesktop environment for Pooled Desktops. The image conformed to testing tool standards and was optimized in accordance with the Citrix Machine Creation Services optimization wizard which is built into the Delivery Controller.

Table 12. Virtual MCS Machine Image Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Pooled Desktops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop operating system</td>
<td>Microsoft Windows 10 (64-bit)</td>
</tr>
<tr>
<td>Hardware</td>
<td>VMware Virtual Hardware Version 11</td>
</tr>
<tr>
<td>vCPU</td>
<td>2</td>
</tr>
<tr>
<td>Memory</td>
<td>2048 MB</td>
</tr>
<tr>
<td>Memory reserved</td>
<td>2048 MB</td>
</tr>
<tr>
<td>Video RAM</td>
<td>35 MB</td>
</tr>
<tr>
<td>3D graphics</td>
<td>Off</td>
</tr>
<tr>
<td>NIC</td>
<td>1</td>
</tr>
<tr>
<td>Virtual network adapter 1</td>
<td>VMXNet3 adapter</td>
</tr>
<tr>
<td>Virtual SCSI controller 0</td>
<td>LSI</td>
</tr>
<tr>
<td>Virtual disk: VMDK 1</td>
<td>34 GB</td>
</tr>
<tr>
<td>Virtual floppy drive 1</td>
<td>Removed</td>
</tr>
<tr>
<td>Virtual CD/DVD drive 1</td>
<td>Pass-through IDE</td>
</tr>
<tr>
<td>Applications</td>
<td>• Login VSI 4.1.4 application installation</td>
</tr>
<tr>
<td></td>
<td>• Adobe Acrobat 11</td>
</tr>
<tr>
<td></td>
<td>• Adobe Flash Player 16</td>
</tr>
<tr>
<td></td>
<td>• Doro PDF 1.82</td>
</tr>
<tr>
<td></td>
<td>• FreeMind</td>
</tr>
<tr>
<td></td>
<td>• Microsoft Internet Explorer 11</td>
</tr>
<tr>
<td></td>
<td>• Microsoft Office 2016 (64-bit)</td>
</tr>
<tr>
<td>VMware tools</td>
<td>Release 10.0.0.3000743</td>
</tr>
<tr>
<td>Citrix VDA</td>
<td>Version 7.8</td>
</tr>
</tbody>
</table>

When using Cisco HX Data Platform Data Store for Citrix desktops deployed with Machine Creation Services (MCS) technology, Cisco recommends to use seSparse disk format when building master Virtual Machine for optimal performance.
Creating Virtual Machine with seSparse disk

Step 1 – In vSphere Web Client create a diskless Virtual Machine with all other necessary parameters, such as OS, number of vCPU, amount of memory, and specific networking, configured for your environment.

![Virtual Machine Configuration](image)

Step 2 – Create seSparse formatted disk

1. login to the EXS shell of one of the HX cluster hosts and browse to the VM folder on the HX datastore:
   - cd /vmfs/volumes/<datastore-id>/<VM_Name>
   - e.g. cd /vmfs/volumes/ae706752-328c3938/XDBase4MCS/
2. Create disk using `vmkfstools` utility:
   - `vmkfstools -c <DiskSize> -d sesparse VM_name.vmdk`
   - e.g. `vmkfstools -c 20g -d sesparse XDBase4MCS.vmdk`
Step 3 – attached newly created disk to the master Virtual Machine

1. Using VMware Web Client browse to your VM created in the step 1.

2. Right-Click on the VM and select Edit Settings

3. From New Device drop down list select Existing Hard Disk click Add.

4. Browse datastore to master VM folder and select the disk created in the step 2
5. Verify the disk has a proper format (Flex-SE)

Virtual Machine is ready for OS deployment and further configuration.
Importing VM to use seSparse formatted disk

Additionally, exiting OVA/OVF package can be imported using VMware ovftool from CMD and using `-dm/-

diskMode` to specify target disk format as `seSparse` (VI target).

```
  ovftool.exe -dm=seSparse -ds="destination_datastore" --
  net: 'OVF Network=New Network' OVA.ova
  "vi://vcenter/datacenter/host/cluster_name"
```

E.g.

```
  ovftool.exe --noSSLVerify --X:logFile=upload.log --
  X:logLevel=verbose -dm=seSparse -ds=HX-XD-DS --net: 'VDI
  Network=VDI' H:\Vadim\win7sp1x86-image\win7sp1x86.ova
  "vi://10.10.30.20/VDILAB-HX/host/C1-XD-HX"
```

Opening OVA source: H:\Vadim\win7sp1x86-

image\win7sp1x86.ova

Enter login information for target vi://10.10.30.20/

```
Enter username and password (in URL safe mode – substitute special characters like @, / or ! for %40, %2F

or %21)

Username: administrator%40vsphere.local
Password: **********
```

Opening VI target:

```
  vi://administrator%40vsphere.local@10.10.30.20:443/VDILAB-
  HX/host/C1-XD-HX
```

Progress will be shown in CMD

```
  Deploying to VI:
  vi://administrator%40vsphere.local@10.10.30.20:443/VDILAB-
  HX/host/C1-XD-HX
  Progress: 16%
```

and in vCenter

Conclusion

This Cisco HyperFlex solution addresses urgent needs of IT by delivering a platform that is cost effective and

simple to deploy and manage. The architecture and approach used provides for a flexible and high-performance

system with a familiar and consistent management model from Cisco. In addition, the solution offers numerous

enterprise-class data management features to deliver the next-generation hyperconverged system.

Delivering responsive, resilient, high performance Citrix XenDesktop Windows 7 and Windows 10 Virtual Machines

using Citrix Provisioning Services or Citrix Machine Creation Service has many advantages for desktop

virtualization administrators.

Virtual desktop end-user experience, as measured by the Login VSI tool in benchmark mode, is outstanding with

Intel Haswell E5-2600 v4 processors and Cisco 2400Mhz memory. In fact, we have set the industry standard in

performance for Desktop Virtualization on a hyper-converged platform.
For More Information

The following documents, available from Cisco Online Support, provide additional relevant information. If you do not have access to a document, please contact your Cisco representative.

- Cisco Hx220c M4 HyperFlex Node Installation Guide:
- Cisco HyperFlex Systems Getting Started Guide:
- Cisco HyperFlex Systems Administration Guide:

The following documents, located on the VMware website, provide additional relevant information:

- VMware vSphere Networking Guide:
- VMware vSphere Storage Guide:
- VMware vSphere Virtual Machine Administration:
- VMware vSphere Virtual Machine Administration Guide:
- VMware vSphere Installation and Setup:
- VMware vCenter Server and Host Management Guide:
- VMware vSphere Resource Management:
- Interpreting VMware ESXTOP Statistics:
  [https://communities.vmware.com/docs/DOC-9279](https://communities.vmware.com/docs/DOC-9279)
- Preparing VMware vCenter Server Databases:
- Understanding Memory Resource Management in VMware vSphere:
• Citrix Reference links for XD 7.8 and PVS 7.8
  ◦ http://docs.citrix.com/en-us/provisioning/7-8.html