Technical White Paper: **August 2022**

VMware Validated Solutions for Cloud Providers: Scale and Performance Guidelines

for VMware Cloud Director 10.2 – 10.4 environments

vmware®

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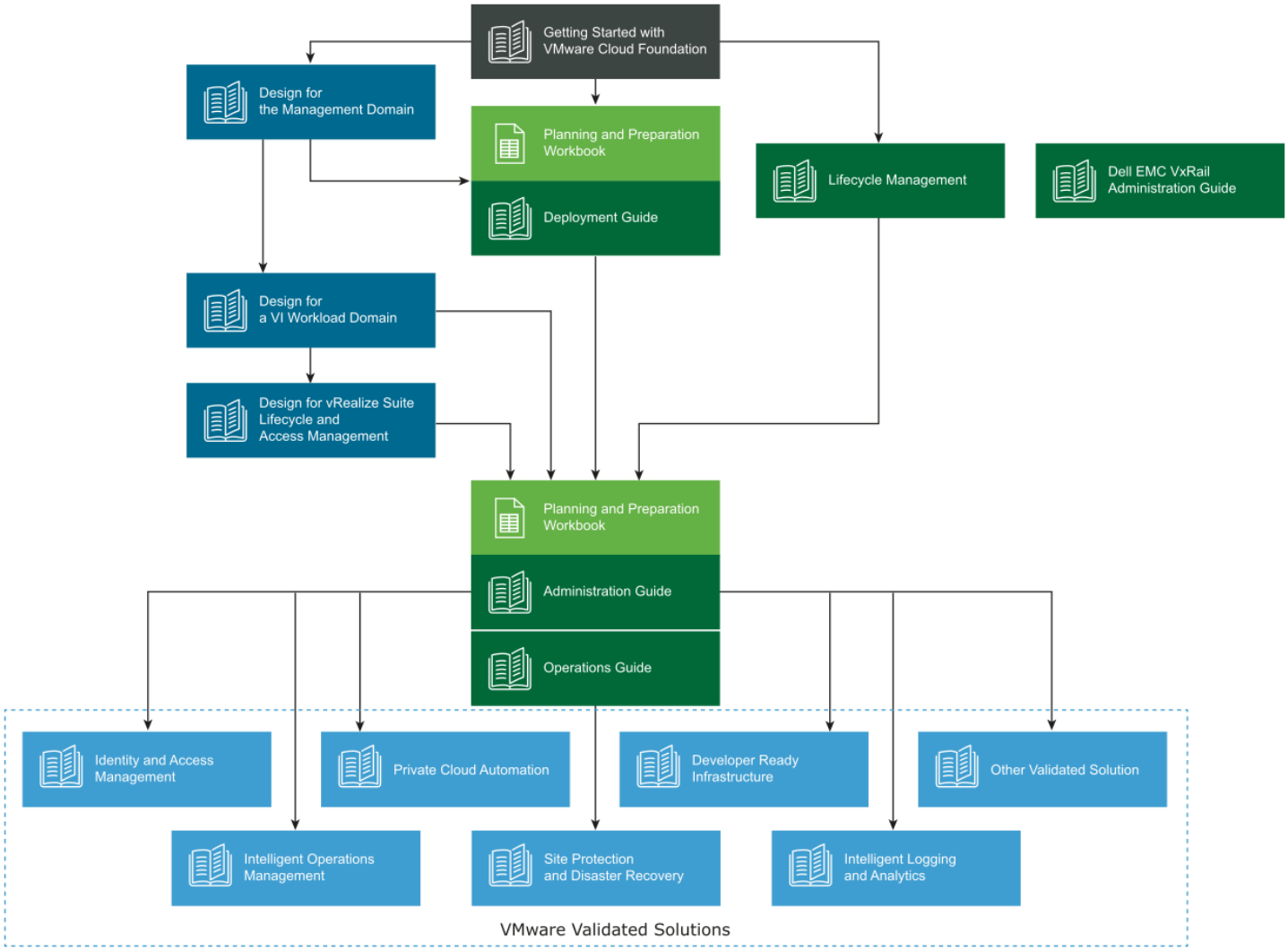
Introduction

The VMware Validated Solutions (VVS) for Cloud Providers: Scale and Performance Guidelines documents a pre-validated set of software components that simplify the deployment of a VMware Cloud Director® - based multitenant cloud in a predictable and efficient manner. While not a VMware Validated Solution by itself, it builds on the design guidance of the VMware Cloud Foundation™ documentation set and VMware Validated Solutions implemented on VMware Cloud Foundation.

Starting with VMware Cloud Foundation 4.3, the VMware Validated Design guidance for the SDDC components natively supported by the VMware Cloud Foundation automation is moved to the VMware Cloud Foundation documentation and the guidance for the solutions on top of VMware Cloud Foundation is now published under a new class of technical reference implementations called VMware Validated Solutions. VMware Validated Design documentation is discontinued.



Validated Solutions are a vetted portfolio of technical validated solutions designed to help build secure, high-performing, resilient and efficient infrastructure for applications and workloads deployed on VMware Cloud Foundation. Each VMware Validated Solution is fully validated by expert VMware solution architects and can be deployed out of the box with VMware Cloud Foundation. Each solution includes detailed design with design decisions, implementation procedures and, where applicable, automated steps using infrastructure-as-code using Terraform, PowerShell and operational guidance. These

solutions also include a Time-to-Deploy value that provides an estimated time to deploy the solution, helping VI admins and architects to plan and deploy the solution.

The Scale and Performance Guidelines documents a validated VMware Cloud Provider Platform stack and associated scale and performance benchmarking captured during validation testing. It details what components are needed, which versions have received additional validation, and what kind of scale and performance VMware Cloud Providers can expect with a similar deployment. Additionally, the test data provided may be useful in extrapolating potential performance for smaller and larger scale deployments or different performance compute platforms.

With this document VMware Cloud Providers get clarity and predictability about which version of each software component of the VMware Cloud Provider Platform stack is recommended for use with a specific VMware Cloud Foundation version and associated VMware Validated Solutions. Each Scale and Performance version also includes a predictable support timeframe for the VMware Cloud Provider Platform stack, typically 12 – 18 months from the launch of the corresponding VMware Cloud Director major version release. This reduces the expense and time involved in deciding what components to upgrade when and to which version, so that the entire software stack stays in support and incompatible combinations are avoided.

It is not the current intent of Scale and Performance to push VMware Cloud Director to its absolute limits. For configuration maximums and limits, see VMware Cloud Director Configuration Maximums.

This document also includes the expected performance as observed by tenant users and VMware Cloud Provider administrators interacting with the VMware Cloud Director user interface and API.

The use of the new VMware Cloud Provider Lifecycle Manager™ is encouraged when deploying new environments. VMware Cloud Provider Lifecycle Manager is a tool for automating the deployment and lifecycle management of VMware Cloud Provider Platform components like Cloud Director, Tenant App, and Usage Meter. VMware Cloud Provider Lifecycle Manager helps to deliver a prescriptive deployment architecture based on best practices and validated designs.

Benefits

VMware Cloud Providers who deploy the core technologies outlined in this VVS for Cloud Providers and who meet other programmatic requirements are also eligible to apply for the VMware Cloud Verified designation. Partners who are awarded the VMware Cloud Verified badge are promoted to VMware customers as specialists who can help them seamlessly run, manage, connect and secure their applications across private and public clouds in their familiar VMware cloud infrastructure environment. To receive the VMware Cloud Verified badge, VMware Cloud Providers must meet requirements and apply directly via the VMware Technology Validation page. For complete requirements and detailed application process, please refer to How to Achieve Cloud Verified and Cloud Verified Application Process documents.

One of the program requirements is to be running one of the software version stacks defined in this document as listed in TABLE 1. BILL OF MATERIALS. Please note that older stack versions listed in the table may be restricted to use for revalidation only. See the table footnotes for details. Products are expected to be patched with any required *minor* patch versions without impact to the Cloud Verified application process or status.

Audience

This document is intended for VMware Cloud Provider architects and technical leads responsible for planning and performing the deployment and upgrades of a VMware-based cloud environment.

Scope

This document addresses the following:

Interoperability stack

Provides a list of certified *major* product versions of all the component software comprising the software stack. Using the recommended major versions guarantees known support life of the stack as well as performance characteristics.

Scale and Performance

The certified solution stack provides known performance and scale characteristics and includes recommendations and guidelines for hardware and scale based on anticipated tenant demand. A VMware Cloud Director-based platform can be properly sized by following the sizing guidelines for hardware and scale based on anticipated tenant demand.

Sizing guidelines and software requirements

VMware Cloud Providers also benefit from clear guidelines for sizing hardware and software components to match their expected tenant load. While the Scale and Performance Guidelines does not cover every cloud configuration and size, it provides a sizing recommendation for a "typical" medium size cloud as representative of a broad set of VMware Cloud Providers. Data from VMware Cloud Providers was categorized into small (Profile A), medium (Profile B) and large (Profile C) size deployment profiles.

For additional guidance beyond the scope of this document see the complimentary documents that are part of the VMware Cloud Foundation Documentation and VMware Validated Solutions Documentation. Many of these are referenced throughout this document. Always refer to the VMware Product Interoperability Matrices as the authoritative resource for interoperability between the VMware software components mentioned in this guide. It is also important to remember that a compliant solution must follow all relevant security guidelines outlined in the product-specific and VMware Validated Solutions documentation.

Interoperability Stack (Bill of Materials)

The Bill of Materials table lists the pre-validated set of software components for Cloud Providers at the time of the Scale and Performance testing. While VMware Cloud Providers are free to use versions based on the full interoperability matrix or different combinations of VMware Cloud Provider Program software products, the specified stack guarantees a known predictable support time and specific performance and scaling characteristics. Performance and scaling information is supplied later this document. Products marked "Core" must be deployed to officially achieve Cloud Verified compliance but only need to adhere to the major product version listed below with the expectation that the latest patches will be applied by Cloud Providers as needed while adhering to the VMware Product Interoperability Matrix. See TABLE 9. VMWARE SOFTWARE VERSIONS for a detailed list of specific patch versions used in the test environment.

TABLE 1. BILL OF MATERIALS

BILL OF MATERIALS [1]					
COMPONENT	Current Validated Stacks			CORE/ OPTIONAL	NOTES
	10.2 [2]	10.3	10.4		
VMware Cloud Foundation™	4.1 or 4.2	4.2 or 4.3	4.4	Optional	See the VMware Cloud Foundation Documentation
VMware Cloud Foundation™ SDDC Manager™	4.1 or 4.2	4.2 or 4.3	4.4	Optional	Bundled as part of VMware Cloud Foundation
VMware vCenter Server®	7.0	7.0	7.0	Core	Bundled as part of VMware Cloud Foundation
VMware ESXi™	7.0	7.0	7.0	Core	Bundled as part of VMware Cloud Foundation
VMware vSAN™	7.0	7.0	7.0	Core [3]	Bundled as part of VMware Cloud Foundation
VMware NSX®	3.0 or 3.1	3.1	3.1	Core	Bundled as part of VMware Cloud Foundation [4]
VMware vRealize Suite® Lifecycle Manager™	8.1 or 8.2	8.2 or 8.4	8.6	Optional	Bundled as part of VMware Cloud Foundation
VMware vRealize Operations™	8.1 or 8.2	8.5	8.6	Optional	See the VVS Intelligent Operations Management
VMware vRealize® Log Insight™	8.1 or 8.2	8.2	8.6	Optional	See the VVS Intelligent Logging and Analytics
VMware vRealize® Network Insight™	5.3 or 6.1	6.1	6.5	Optional	

[1] These are the recommended set of products, but this is not a full interoperability matrix. VMware Cloud Director is supported with multiple versions of each product listed but in the current benchmarking we used a specific product version. Test results generally apply to all patches within the specified major version of each component. See the VMware Product Interoperability Matrix for full Cloud Director interoperability information

[2] Eligible for existing VMware Cloud Verified partner revalidation only

[3] vSAN-based storage must be deployed in at least one cluster (either management or capacity).

[4] NSX-v has reached end of general support and is no longer included in the VVS as of 10.2

BILL OF MATERIALS [1]					
COMPONENT	Current Validated Stacks			CORE/ OPTIONAL	NOTES
	10.2 [2]	10.3	10.4		
VMware NSX® Advanced Load Balancer™	20.1	20.1	21.1	Optional	See the VVS Advanced Load Balancing
VMware Cloud Provider Lifecycle Manager	N/A	N/A	1.3	Optional	See the VMware Cloud Provider Lifecycle Manager Documentation
VMware Cloud Director	10.2 – 10.2.2.3	10.3 – 10.3.3.2	10.4	Core	Bundled as part of VMware Cloud Provider Lifecycle Manager
VMware vCloud® Usage Meter™	4.3+	4.4+	4.5+	Core	UM can be any higher version. Bundled as part of VMware Cloud Provider Lifecycle Manager
VMware vRealize Operations Tenant App for VMware Cloud Director	2.5	2.6	8.6	Optional	Bundled as part of VMware Cloud Provider Lifecycle Manager
VMware Cloud Director Availability™	4.1	4.2	4.4	Optional	
VMware Cloud Director Container Service Extension	3.0	3.1	3.1	Optional	
VMware vRealize® Orchestrator™	8.2 or 8.3	8.3	8.8	Optional	Apply the latest available patch.
VMware Cloud Director™ App Launchpad™	2.0	2.0	2.1	Optional	
VMware Cloud Director™ Object Storage Extension™	2.0	2.0	2.1	Optional	

Scale and Performance

The Scale Profile B table defines a common environment similar to the environments of approximately 60% of all VMware Cloud Providers. While VMware Cloud Director is capable of a larger scale, the following profile is what is validated and benchmarked for Scale and Performance.

TABLE 2. SCALE PROFILE B

Scale Profile B	
Parameter	Value
Number of tenants (Organizations in Cloud Director)	400
Number of powered-on tenant virtual machines (with an OS installed)	10,000
Number of physical data centers	1
Number of VMware Cloud Director cells	5 (1 primary, 2 standby cells, 2 application cells)
Number of VMware vCenter Server instances managed by VMware Cloud Director	3 VMware vCenter Server instances for resource capacity

Scale Profile B	
Parameter	Value
Maximum network latency from VMware Cloud Director to VMware vCenter Server and VMware NSX-T Manager™	Network RTT latency up to 150 ms
Concurrent API operations	Up to 128 concurrent users running operations against the VMware Cloud Director API
Concurrent virtual machine migrations to VMware Cloud Director from tenant environments by VMware Cloud Director Availability	100

Performance Characteristics

Environment Setup

The VMware Cloud Provider Platform environment is set up based on Scale Profile B.

Testing is performed at different levels of network latency from VMware Cloud Director cells to VMware vCenter Server and VMware NSX-T Manager to measure the impact of network latency on performance.

Performance and Throughput

The test throughput is measured as the number of operations performed over 30 minutes. The test was run with different test concurrency (32, 64, and 128) and network latency (0.3 ms, 40 ms, and 150 ms). During this test, a representative random sample of operations from the TABLE 10. VMWARE CLOUD DIRECTOR OPERATIONS is used.

TABLE 3. PERFORMANCE AND THROUGHPUT

PERFORMANCE AND THROUGHPUT				
Network latency impact on operations		Successfully completed operations per minute		
Concurrency (Number of concurrent users)	Latency (Milliseconds)	10.2	10.3	10.4
32	0.3 MS	144	147	123
	40 MS	136	138	112
	150 MS	115	123	110
64	0.3 MS	268	274	245
	40 MS	242	259	228
	150 MS	215	234	204
128	0.3 MS	431	453	405
	40 MS	380	435	387
	150 MS	356	420	310

API Latency

The API Operations Latency table shows average user observed latency (in seconds) for a selection of API operations at RTT = 0.3 ms. See TABLE 10. VMWARE CLOUD DIRECTOR OPERATIONS for the full list of operations invoked during this test.

TABLE 4. API OPERATIONS LATENCY

API OPERATIONS LATENCY				
CONCURRENCY impact on operations		LATENCY (seconds)		
Concurrency (Number of concurrent OPERATIONS)	OPERATION	10.2	10.3	10.4
32	Instantiate a 150 MB vApp from a template	17 s	20 s	23 s
	Create an edge gateway	6 s	8 s	10 s
	Create an independent disk	9 s	9 s	11 s
64	Instantiate a 150 MB vApp from a template	18 s	21 s	25 s
	Create an edge gateway	7 s	9 s	12 s
	Create an independent disk	10 s	10 s	12 s
128	Instantiate a 150 MB vApp from a template	25 s	28 s	32 s
	Create an edge gateway	9 s	11 s	13 s
	Create an independent disk	13 s	13 s	14 s

Increasing the network RTT from 0.3 ms to 150 ms affects these numbers with the size of the effect varying significantly depending on the operation. With most API operations RTT increase from 0.3 ms to 150 ms caused the latency to increase by a factor of 2 or less.

Upload and Download Performance

The OVF upload and download times observed in the test environment vary depending on the different network latencies.

TABLE 5. OVF UPLOAD AND DOWNLOAD TIMES

OVF UPLOAD AND DOWNLOAD TIMES				
LATENCY (MILLISECONDS)	OPERATION	10.2	10.3	10.4
0.3	OVF upload time in seconds (4 GB)	306	292	364
	OVF download time in seconds (4 GB)	233	194	280
40	OVF upload time in seconds (4 GB)	322	320	381
	OVF download time in seconds (4 GB)	234	195	289
150	OVF upload time in seconds (4 GB)	325	323	395
	OVF download time in seconds (4 GB)	238	197	293

VMware Cloud Director Availability

The Time to Protect a VM in VMware Cloud Director Availability represents the time to establish replication of virtual machines of various sizes between a VMware Cloud Director and a DR target vCenter environment. 10 GB uplinks were configured between VMware vCenter Server and VMware Cloud Director. Network throughput was stable around 990 Mbps.

TABLE 6. TIME TO PROTECT A VM

TIME TO PROTECT A VM			
	Time to Protect		
VM size	10.2	10.3	10.4
1 GB	35 seconds	32 seconds	38 seconds
10 GB	4 minutes	3 minutes	2 minutes 42 seconds
100 GB	20 minutes	18 minutes	17 minutes
500 GB	2 hours 4 minutes	1 hours 45 minutes	1 hours 32 minutes
1 TB	3 hours 56 minutes	3 hours 20 minutes	3 hours 12 minutes

The Network Latency Impact on Migration Performance table displays how the network latency from VMware Cloud Director cells to VMware vCenter Server and NSX-T Manager impacts cold migration for virtual machines of 100 GB size.

TABLE 7. NETWORK LATENCY IMPACT ON TIME TO PROTECT (VM SIZE = 100 GB)

NETWORK LATENCY IMPACT ON TIME TO PROTECT (VM SIZE = 100 GB)			
RTT Latency between VMWARE vCenter Server and VMware Cloud Director	Time to Protect		
	10.2	10.3	10.4
0.3 ms	20 minutes	18 minutes	17 minutes
40 ms	27 minutes	19 minutes	18 minutes
150 ms	30 minutes	21 minutes	20 minutes

Sizing Guidelines

Many environment variables influence the number of hosts and CPU and memory resources required to run a cloud service based on VVS for Cloud Providers. It is impossible to give a precise formula for how much of each resource is required. The current effort focuses on demonstrating how our deployment setup behaves in terms of scale and performance under the defined test load.

The Scale Profile B captures the parameters of the load on the system in terms of number of tenants, organizations, VMs, network latency, and cloud management operations load. The results in terms of average response time, throughput, and uptime under these controlled conditions provide a starting point for Cloud Providers to estimate how much capacity is needed for their use cases. We strongly recommend that Cloud Providers extensively test each environment prior to production use to ensure that the performance meets the business SLAs.

VMware Cloud Director Virtual Appliance

The VVS for Cloud Providers recommends the use of a VMware Cloud Director virtual appliance. The virtual appliance includes an embedded PostgreSQL database fully managed by VMware Cloud Director with built-in replication for maintaining consistency between cells. A properly configured virtual appliance cluster is also resilient to failures of individual cells.

The recommended virtual appliance deployment includes 1 primary cell, 2 standby cells and 0 or more application cells. See the VMware Cloud Director Installation, Configuration, and Upgrade Guide for more details about the deployment, configuration, and operation of the virtual appliance.

For the purposes of VVS scale and performance benchmarking, the following Extra Large VMware Cloud Director appliance sizing configuration was used: 1 primary cell, 2 standby cells, 2 application cells. The Table 8 Management and Resource Component Sizing gives the details of memory and CPU capacity on each VMware Cloud Director appliance node.

Note that the amount of hardware and software resources deployed is meant to eliminate any resource-related constraints and allow to benchmark performance and stability of the software.

Determining how much hardware and software components are appropriate for a production deployment requires testing. There is no simple formula. However, the following VMware Cloud Director sizing guideline can be used as a starting point:

Start with a Large VMware Cloud Director virtual appliance configuration with 1 primary and 2 standby nodes for environments of scale similar to **Profile B**.

Benchmark the environment performance under a production-like load. Add application cells as needed to achieve desired throughput and response times.

The embedded PostgreSQL database is automatically configured. However, some post-deployment tuning might be needed for best performance. See the section VMware Cloud Director Appliance PostgreSQL Tuning for the database parameters used in this benchmarking.

Management and Resource Component Sizing

The following table summarizes sizing choices made for various management and resource components of the test environment.

TABLE 8. MANAGEMENT AND RESOURCE COMPONENT SIZING

Component	Size [5]	Resources	Notes
Management VMware vCenter Server (VMware vCenter Server with an embedded Platform Services Controller)	Small	RAM: 19 GB CPU: 4 Storage: 480 GB	1 management vCenter Server Use the Deployment Model for vCenter Server for the Management Domain
Resource VMware vCenter Server (VMware vCenter Server with an embedded Platform Services Controller)	Large	RAM: 37 GB CPU: 16 Storage: 1065 GB	Resource VMware vCenter Server instances. VMware Cloud Foundation deploys medium VMware vCenter Server instances by default. The size is increased to Large Use the Deployment Model for vCenter Server for a Virtual Infrastructure Workload Domain
VMware ESXi™		**Management Cluster** RAM: 2.5 TB CPU: 364 Cores Storage: 21 TB vSAN, 14 TB iSCSI **Resource Clusters** RAM: 1.7 TB CPU: 252 Cores Local Cluster Storage: 15 TB vSAN, 4 TB iSCSI Shared Storage: 10 TB iSCSI	1 management cluster, 3 resource clusters Use the Sizing Compute Resources for ESXi for the Management Domain Use the Sizing Compute Resources for ESXi for a Virtual Infrastructure Workload Domain
VMware vSAN (deployed in Management VMware vCenter Server instance)		21 TB	1 VMware vSAN Cluster for Management VMware vCenter Server instance Use Designing and Sizing a vSAN Cluster
VMware vSAN (deployed in Resource VMware vCenter Server instances)		15 TB (For each Resource VMware vCenter Server instance)	1 VMware vSAN Cluster per Resource VMware vCenter Server instance (3 Resource VMware vCenter Server instances)

5 Unless otherwise noted the component sizing applies to all VVS versions.

Component	Size [5]	Resources	Notes
VMware NSX-T	**Manager** Size: Large	**Manager** RAM: 48 GB CPU: 12 Storage: 300 GB	1 Management VMware NSX-T Manager Cluster (3 VMware NSX-T nodes) 3 Workload VMware NSX-T Manager Clusters (3 VMware NSX-T nodes for each Workload VMware NSX-T Manager Cluster) Use the Deployment Model for NSX Manager for the Management Domain Use the Deployment Model for NSX Manager for a VI Workload Domain
	Edge Size: Large	**Edge** RAM: 32 GB CPU: 8 Storage: 200 GB	1 Management VMware NSX-T Edge Cluster (2 VMware NSX-T Edge nodes) 3 Workload VMware NSX-T Edge Clusters (2 VMware NSX-T Edge nodes for each Workload VMware NSX-T Edge Cluster) Use the Deployment Model for the NSX Edge Nodes for the Management Domain Use the Deployment Model for the NSX Edge Nodes for a Virtual Infrastructure Workload Domain
VMware Cloud Director	**Virtual appliance** **Extra Large Configuration** 1 Primary (Large) 2 Standby cells (Large) 2 Application Cells (Large)	**Each Primary and Standby Cell** RAM: 32 GB CPU: 24 Storage: 202 GB **Each Application Cell** RAM: 8 GB CPU: 8 Storage: 132 GB	1 TB VMware vSAN File Service NFS storage for the VMware Cloud Director transfer service. Increased root partitions to 50 GB for logs Increased PostgreSQL database disks to 150 GB Use the VMware Cloud Director Appliance Sizing Guidelines
VMware Cloud Director Database			Database is embedded with the VMware Cloud Director virtual appliance
VMware Cloud Director Availability	1 Cloud Replication Management Appliance	CPU: 2 RAM: 4 GB CPU: 2 Storage: 10 GB	
	1 Cloud Replicator Appliance	RAM: 6 GB CPU: 4 Storage: 10 GB	
	1 Cloud Tunnel Appliance	RAM: 2 GB CPU: 2 Storage: 10 GB	

Component	Size [5]	Resources	Notes
	5 On-Premises Appliances	RAM: 4 GB CPU: 4 Storage: 10 GB	
VMware Cloud Director Container Service Extension		RAM: 4 GB CPU: 2 Storage: 50 GB	
VMware Cloud Director AMQP (Rabbit MQ)			Cluster with 2 nodes
VMware Cloud Director Metrics Database (Cassandra)		RAM: 8 GB CPU: 4 Storage: 120 GB	Cluster with 4 nodes 100GB Dedicated for Keyspace data
VMware Cloud Foundation SDDC Manager		RAM: 16 GB CPU: 4 Storage: 816 GB	
VMware vRealize Log Insight	**Primary** Large (1 node) **Worker** Large (2 nodes)	**Primary** RAM: 32 GB CPU: 16 Storage: 1030 GB **Worker** RAM: 32 GB CPU: 16 Storage: 1030 GB	Use the vRealize Log Insight Sizing Calculator
VMware vRealize Network Insight	**Platform** Large (3 nodes) **Collector** Large (3 nodes)	**Platform** RAM: 48 GB CPU: 12 Storage: 1 TB **Collector** RAM: 8 GB CPU: 16 Storage: 215 GB	Use the vRealize Network Insight System Recommendations and Requirements
VMware vCloud Usage Meter	Standard	RAM: 8 GB CPU: 2 Storage: 60 GB	
VMware Identity Manager™		RAM: 6 GB CPU: 2 Storage: 60 GB	

Component	Size [5]	Resources	Notes
VMware vRealize Orchestrator		RAM: 12 GB CPU: 4 Storage: 200 GB	
VMware vRealize Orchestrator plug-in for VMware Cloud Director			
VMware vRealize Operations Manager	**Primary** Size: Large **Primary Replica** Size: Large **Data** Size: Large	**Primary** RAM: 48 GB CPU: 16 Storage: 274 GB **Primary Replica** RAM: 48 GB CPU: 16 Storage: 274 GB **Data** RAM: 48 GB CPU: 16 Storage: 274 GB	1 Primary, 1 Primary Replica, 1 Data node Use the vRealize Operations Sizing Guidelines
VMware vRealize Lifecycle Manager		RAM: 6 GB CPU: 2 Storage: 148 GB	Use the Deployment Model for vRealize Suite Lifecycle Manager
Management Pack for VMware NSX-T			Native Management Pack
Management Pack for VMware vSphere			Native Management Pack
Management Pack for VMware vRealize Log Insight			Native Management Pack
Management Pack for VMware Cloud Director			
Management Pack for VMware vSAN			Native Management Pack
VMware vRealize Operations Tenant App for VMware Cloud Director		RAM: 8 GB CPU: 2 Storage: 72 GB	
VMware Cloud Director App Launchpad			Use the VMware Cloud Director App Launchpad External Components Requirements
VMware Cloud Director Object Storage Extension			Use the Deploying VMware Cloud Director Object Storage Extension

Component	Size [5]	Resources	Notes
VMware NSX Advanced Load Balancer			Use the Sizing Compute and Storage Resources for NSX Advanced Load Balancer Controller(s) Use the Sizing Compute and Storage Resources for NSX Advanced Load Balancer Service Engine(s)

Appendix A – Test Environment and Benchmarking Methods

Test Environment

The test environment includes a management cluster, resource clusters (70% of workloads on vSAN, 30% on iSCSI storage) and a test driver.

Management Cluster

All management components were deployed in a management cluster of 13 physical servers (Cisco UCSC-C240-M5SX). Each server is configured with 192 GB RAM, 28 cores, and vSAN supported SSDs to make up 21 TB vSAN as well as 14 TB iSCSI attached storage.

Figure 1. Management Component Deployment

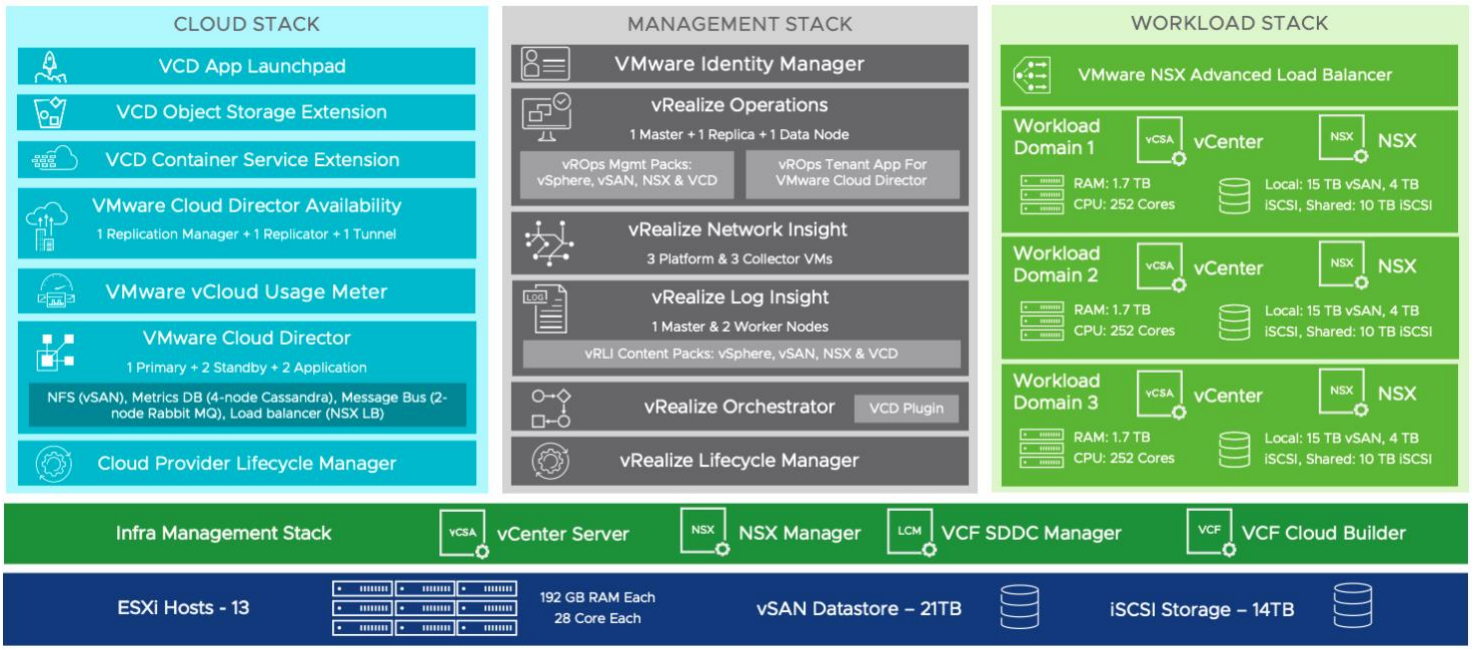
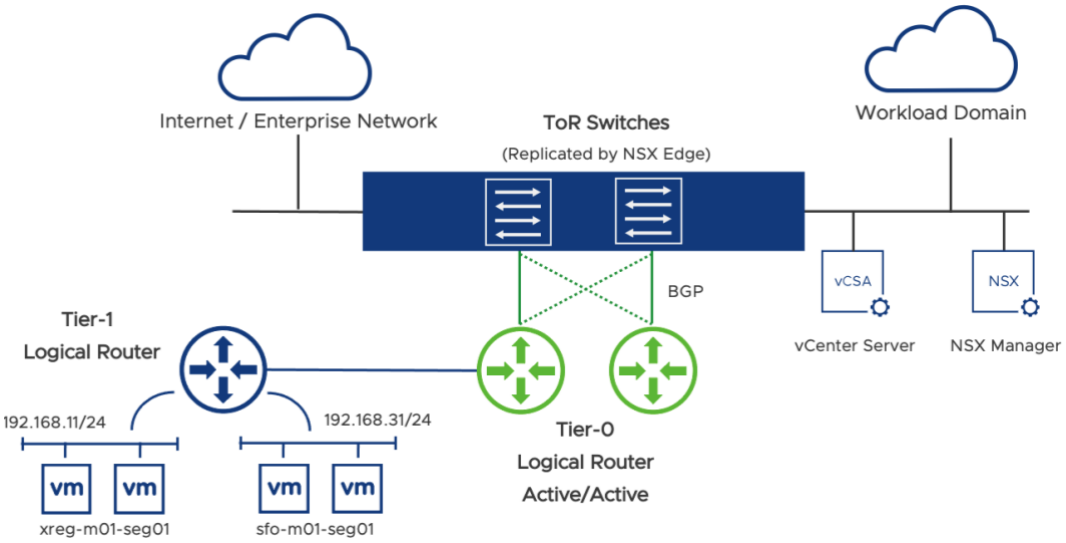


Figure 2. Management Cluster Networking



Resource Cluster

This is where the Tenant Organizations and workload virtual machines were created.

- 27 physical servers (Cisco UCSC-C240-M5SX)
- Each physical server is with 192 GB RAM and 28 cores, each with vSAN supported SSDs
- 15.72 TB vSAN, 10 TB iSCSI (Shared) and 4TB iSCSI for each cluster

Figure 3. Resource Cluster Setup

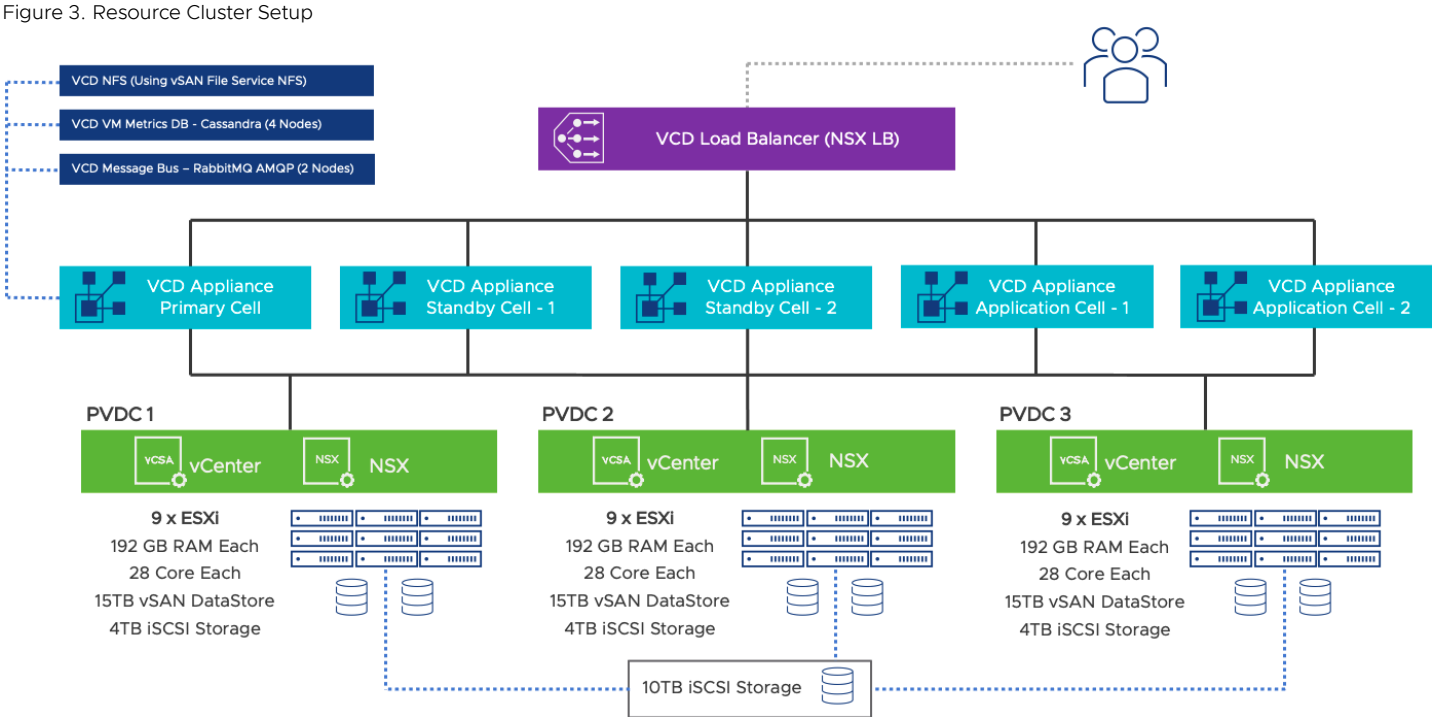
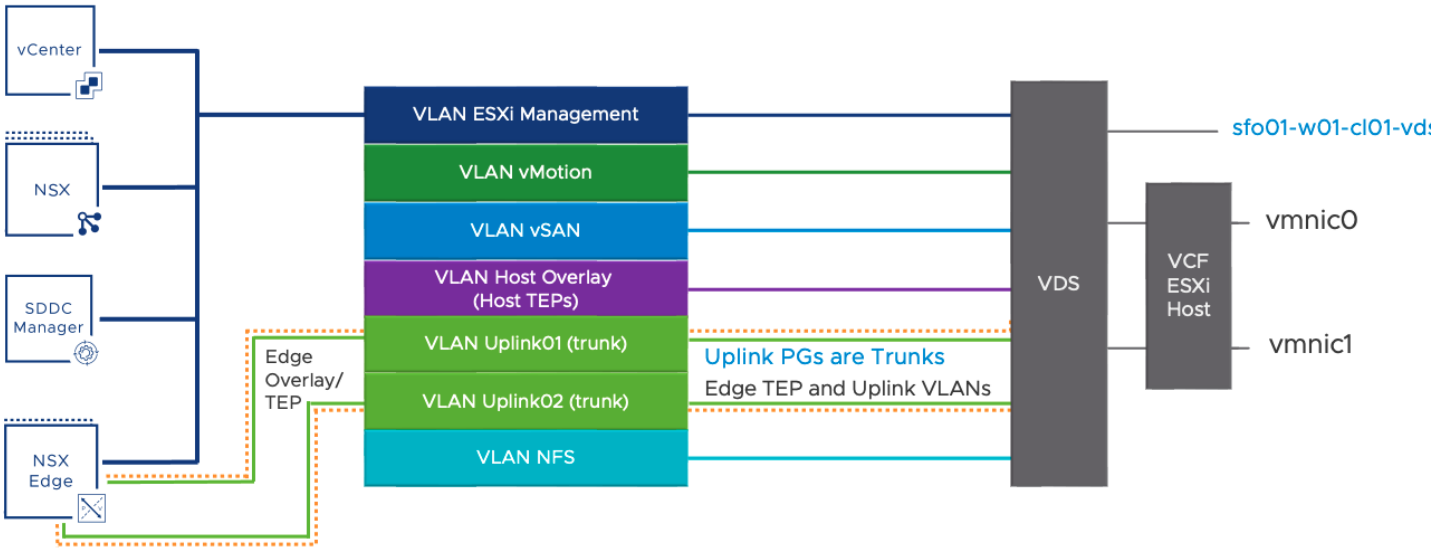


Figure 4. Resource Cluster Networking



Software Versions

The table below provides a detailed list of VMware software version and patch levels used for each test run.

TABLE 9. VMWARE SOFTWARE VERSIONS

Component	TESTED Version AND PATCH LEVEL			
	10.2	10.2.2	10.3	10.4
Management VMware vCenter Server (VMware vCenter Server with an embedded Platform Services Controller)	7.0 U1	7.0U1c	7.0U1c	7.0U3d
Resource VMware vCenter Server (VMware vCenter Server with an embedded Platform Services Controller)	7.0 U1	7.0U1c	7.0U1c	7.0U3d
VMware ESXi™	7.0 U1	7.0U1d	7.0U1d	7.0U3d
VMware vSAN (deployed in Management VMware vCenter Server instance)	7.0 U1	7.0U1d	7.0U1d	7.0U3d
VMware vSAN (deployed in Resource VMware vCenter Server instances)	7.0 U1	7.0U1d	7.0U1d	7.0U3d
VMware NSX-T	3.0.2	3.1.0	3.1.0	3.1.3.7.4
VMware Cloud Director	10.2	10.2.2	10.3	10.4
VMware Cloud Director Database	PostgreSQL 10.12.0	PostgreSQL 10.12.0	PostgreSQL 10.17	PostgreSQL 10.20
VMware Cloud Director Availability	4.1	4.1	4.2	4.4
VMware Cloud Director Container Service Extension	3.0.0	3.0.2	3.1	3.1.4
VMware Cloud Director AMQP (Rabbit MQ)	3.8.9	3.8.14	3.8.14	3.10.5
VMware Cloud Director Metrics Database (Cassandra)	3.11.6	3.11.10	3.11.10	4.0.4
VMware Cloud Foundation SDDC Manager	4.1	4.2	4.2	4.4.1
VMware vRealize Log Insight	8.1.1	8.2	8.2	8.6.2
VMware vRealize Network Insight	5.3	6.1	6.1	6.5.1
VMware vCloud Usage Meter	4.3	4.3	4.4	4.5.0.1
VMware Identity Manager™	3.3.2	3.3.4	3.3.4	3.3.6
VMware vRealize Orchestrator	8.2	8.3	8.3	8.8
VMware vRealize Orchestrator plug-in for VMware Cloud Director	10.0.0.1	10.0.0.1	10.0.0.1	10.3.0.1

Component	TESTED Version AND PATCH LEVEL			
	10.2	10.2.2	10.3	10.4
VMware vRealize Operations Manager	8.1.1	8.2	8.5	8.6.2
VMware vRealize Lifecycle Manager	8.1 Patch 1	8.2 Patch 2	8.2 Patch 2	8.6.2
Management Pack for VMware NSX-T	8.1	8.2	8.5	8.6
Management Pack for VMware vSphere	8.1	8.2	8.5	8.6
Management Pack for VMware vRealize Log Insight	8.1	8.2	8.5	8.6
Management Pack for VMware Cloud Director	5.4	5.4	5.5	8.6.1
Management Pack for VMware vSAN	8.1	8.2	8.5	8.6
VMware vRealize Operations Tenant App for VMware Cloud Director	2.5	2.5	2.6.1	8.6.2
VMware Cloud Director App Launchpad	2.0	2.0	2.0	2.1.1.2
VMware Cloud Director Object Storage Extension	2.0	2.0	2.0	2.1.1
VMware NSX Advanced Load Balancer	20.1.1	20.1.1	20.1.4	21.1.4

VMware Cloud Director Appliance PostgreSQL Tuning

PostgreSQL database parameters were set as follows:

shared_buffers = '7GB';"

effective_cache_size = '21GB';"

work_mem = '8MB' ;"

max_worker_processes = '24';"

maintenance_work_mem = '1GB';"

For some earlier 10.2 & 10.3 versions of VMware Cloud Director appliance these additional PostgreSQL database parameters were set as follows and have now become default settings for later versions and 10.4:

wal_buffers = '16MB';"

max_wal_size = '2GB';"

min_wal_size = '2GB';"

checkpoint_timeout = '5min';"

checkpoint_completion_target = '0.9';"

See Modify the PostgreSQL Configurations in the VMware Cloud Director Appliance from the VMware Cloud Director documentation.

VMware vCenter Server Sizing

The default size for a workload VMware vCenter Server per VMware Cloud Foundation deployment is medium. To support the current scale, the size is changed from medium to large.

VMware NSX-T Tuning

The http properties value of API rate limit, global-api-concurrency, client-api-concurrency-limit on VMware NSX-T Manager must be increased to:

- 500 for global-api-concurrency-limit
- 450 for client-api-concurrency-limit
- 500 for client-api-rate-limit

To update the http properties values on VMware NSX-T Manager:

1. Connect to VMware NSX-T manager as admin user.
2. Run the following commands on VMware NSX-T Manager:

```
set service http global-api-concurrency-limit 500
set service http client-api-concurrency-limit 450
set service http client-api-rate-limit 500
```

Data Plane Rx Ring Size value for all Workload Domain VMware NSX-T Edge Transport Nodes must be increased to 2048. To Update Data Plane Rx Ring Size:

1. Connect to VMware NSX-T Edge Transport Node as admin user.
2. Run the following commands on VMware NSX-T Edge Transport Node:

```
set dataplane ring-size rx 2048
restart service dataplane
```

vRealize Operations vCloud Director Configuration Properties Tuning

The vCloud thread pool properties value must be decreased to as mentioned below:

- RESOURCE_COLLECT_THREAD_POOL_SIZE=10
- RELATIONSHIP_COLLECT_THREAD_POOL_SIZE=30
- METRICS_COLLECT_THREAD_POOL_SIZE=40

See Modifying Configuration Properties from Management Packs for vRealize Operations Manager documentation. For more info follow the latest KB article at https://kb.vmware.com/s/article/81977.

Test Driver

The test driver suite is run from this environment.

- 4 CPU, 8 GB memory, CentOS 7.3

Benchmarking Methods

The testing process is focused primarily on verifying and measuring environment behavior for:

1. Scale - Verify whether the environment meets the Scale Profile B requirement of 10,000 powered-on virtual machines.
2. Performance - Measure the operation latency and throughput when the environment is running at scale (10,000 powered-on virtual machines).
3. Uptime - Verify that the environment can operate at scale with reasonable performance for a long time.
4. The remainder of this section details the exact methods used for testing and measurement.

Scale Test

Scale was carried out with a mix of manual operations and JMeter test tool-based script operations by using the following steps:

1. Create 400 Tenant Organizations in VMware Cloud Director.
2. Create 15,000 virtual machines and power on 10,000 virtual machines across these 400 tenant organizations. All virtual machines were running CentOS with 2 GB disk, 0.5 GB memory.
3. A sample of VMware Cloud Director operations were carried out to verify that the system behaves normally at this scale.

Performance Test

Performance tests were done by performing a well-known distribution of VMware Cloud Director operations with the help of an internal test tool. For the complete operation list, see TABLE 10. VMWARE CLOUD DIRECTOR OPERATIONS.

The following were the key steps in performing and measuring the operations:

1. Scaled up the environment as outlined in the previous section.
2. After the environment was at scale, run a continuous stream of operations for 30 minutes with following distribution:
   - 35-40% vApp operations such as instantiate, deploy, edit, clone, and delete.
   - 25% storage-centric operations such as create, attach, detach, and delete disk.
   - 15% networking-related operations, such as create and delete gateway, routed networks, and firewall configurations.
   - 5% create and delete Orgs, users, catalogs, and virtual data centers.
3. Operations were performed by using VMware Cloud Director local users of different roles (such as **vApp Author**, **Org Admin**, and **System Admin**) with 10% admin roles and 90% user operation roles.
4. Given that most of the operations are asynchronous, the test tool monitors the task returned by VMware Cloud Director to get a completion status and performance time details.
5. Steps 2 to 4 were repeated with 32, 64, and 128 concurrent users to ascertain the ability of the system to deal with concurrent operation invocation.
6. Step 5 was repeated for following latency (between VMware Cloud Director and VMware vCenter Server / VMware NSX-T Manager) values (achieved by artificial latency injection with a tool):
   - 0.3 ms (default)
   - 40 ms
   - 150 ms

Uptime Tests

Uptime tests involved running the environment (based on Scale Profile B) for 5 days and running a constant stream of API calls covering a representative set of operations. The purpose of the test is to establish the API call success rate and system uptime.

1. Tests ran continuously for 5 days.
2. API workflows were triggered by 100 concurrent clients, each client would invoke an operation roughly every 20 seconds. 10,000 powered on VMs
3. No artificial latency injection was done.

TABLE 10. UPTIME TEST RESULTS

UPTIME TEST RESULTS			
	10.2	10.3	10.4
Total Operations completed over 5 days	1,807,200	2,166,574	2,123,280
Average test throughput over 5 days	251 Ops/min	301 Ops/min	295 Ops/min
Success rate	99.95%	99.91%	99.99%

List of Operations

For performance benchmarking, API test clients ran a predetermined distribution across different types of VMware Cloud Director operations as described in the following tables.

TABLE 11. VMWARE CLOUD DIRECTOR OPERATIONS

VMWARE CLOUD DIRECTOR OPERATIONS	
Component	Operations
vApp	• Instantiate a vApp • Deploy (power on) • Edit a vApp • Compose a vApp • Clone a vApp • Power off a vApp • Delete a vApp
Network	• Create a gateway • Create a routed org network • Create an isolated network • Delete an isolated network • Instantiate a vApp • Deploy a vApp • Undeploy a vApp • Delete a gateway • Delete a routed Org network • Delete a vApp
Management	Create an Org Create a user Create an Org VDC Create a VDC network Create a catalog Delete a catalog Delete a VDC network Delete an Org VDC Delete a user

VMWARE CLOUD DIRECTOR OPERATIONS	
Component	Operations
	Delete an Org
NSX Management	Add DNAT/SNAT Add Firewall Rule Delete Firewall Rule Delete DNAT/SNAT
Datastore	• Create a disk • Instantiate a vApp • Attach a disk to a vApp • Detach a disk from a vApp • Delete a disk • Delete a vApp
OVF	OVF upload OVF download

Appendix B – FAQ

Q. How frequently will the Scale and Performance be updated?

We expect to release an updated Scale and Performance with every major VMware Cloud Director release.

Q. How is this document related to the VMware interoperability matrix?

A. The benchmarked stack is a subset of the full interoperability matrix and reflects the exact components we validated and benchmarked in this exercise. The full interoperability includes many more products and versions than what is tested in this exercise

Q. How is the Scale and Performance related to VMware Cloud Foundation?

A. VMware Cloud Foundation is being used to deploy VMware vCenter Server, VMware vSAN, and VMware NSX. It is not required that partners use VMware Cloud Foundation, but it is a supported and recommended option.

Q. Is Scale and Performance suitable for greenfield environments or brownfield environments?

A. Any environment can be made compliant by simply upgrading all its components to the versions listed in the Scale and Performance Bill of Materials. There is no other qualification.

Q. How can we provide input/recommendations for future versions of this doc?

A. Contact the VMware Cloud Director team at vcd-feedback@vmware.com or reach out to your VMware account team and pass your feedback through them.

Q. What is the support model for an environment configured according to these guidelines?

A. Each component of the Cloud Provider Platform stack is supported according to its support lifecycle. A cloud deployment compliant with the Bill of Materials is in support for at least 12 months after the Scale and Performance release date.

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