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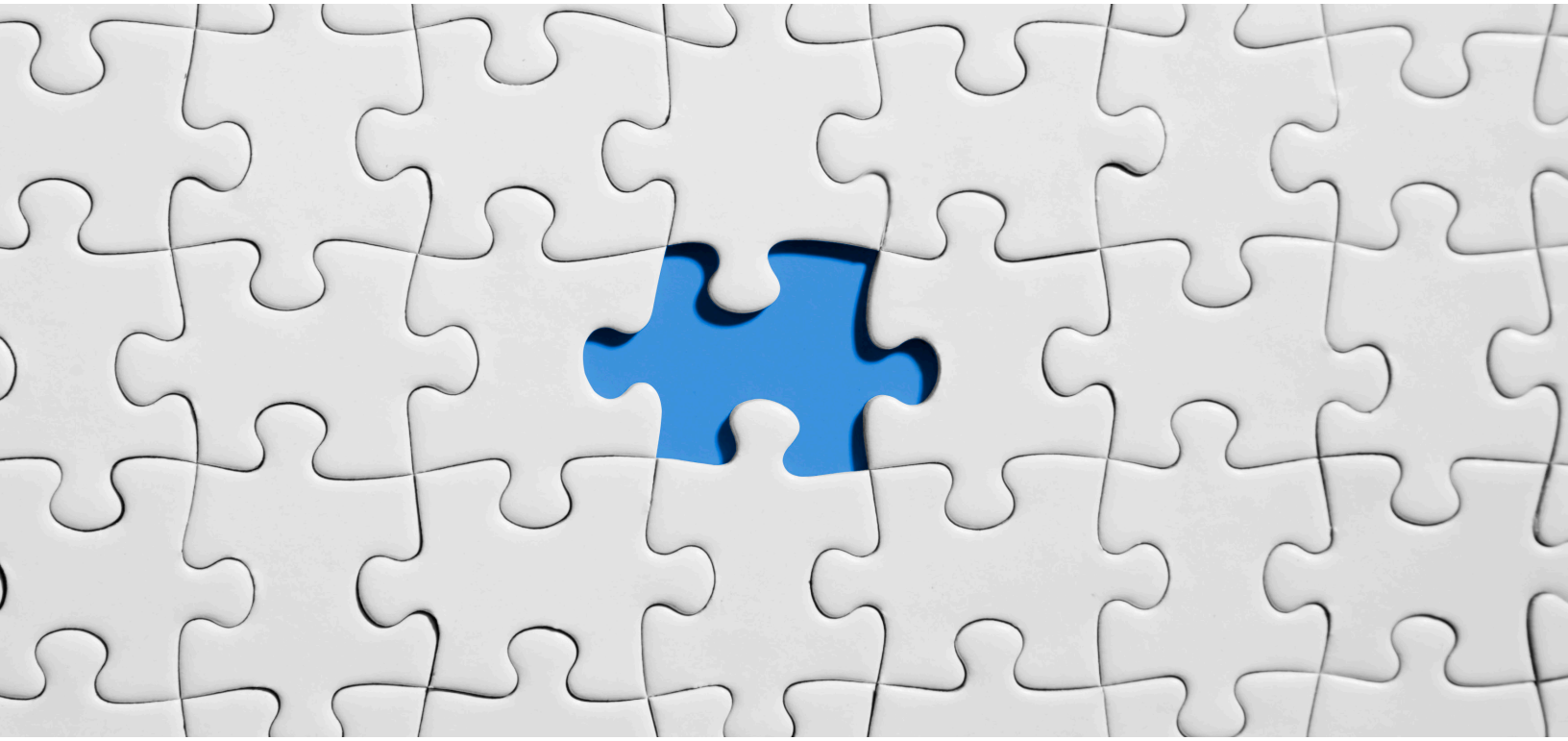
VMWARE CLOUD FOUNDATION - REDEFINING SOFTWARE-DEFINED DATACENTERS



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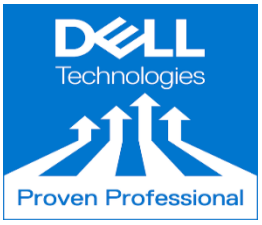

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Overview

Industries are undergoing digital transformation on a path to innovate and adapt to new customer behavior. This rapid pace of change requires a cloud platform that can be quickly deployed and consumed. VMware Cloud Foundation combines VMware's leading technologies to deliver a standardized software defined datacenter (SDDC) platform to environments of all size.

VMware Cloud Foundation provides automated end to end lifecycle management combines compute, network and storage virtualization as well as cloud management into as single solution.

VMware Cloud Foundation (VCF) on VxRail provides the simplest path to a multi-cloud solution through automated deployment of a fully integrated platform that leverages native VxRail hardware and software capabilities paired with VMware's stack. These components work together to deliver a new turnkey solution.

VCF on VxRail is engineered to standardize the architecture of all SDDC components like vSphere, VSAN, and NSX to provide time to value from the large-scale data center to edge locations. Another important aspect is lifecycle automation provided by Cloud Foundation, that streamlines the upgrade experience for the full SDDC software and hardware stack.

Architecture

VMware Cloud Foundations support two Architecture Models – standard and consolidated. Both architecture models are based on the concept of workload domains. A workload domain can be visualized as carved out pooled container of compute, storage and networking resources from the available resources within VMware Cloud Foundation System. A workload domain consists of one or more ESXi vSAN Clusters with NSX Networking. In VCF, there are different types of workload domains

- **Management Workload Domain**
  Management Workload Domain is created during the initial bring-up of VMware Cloud Foundations system. Management workload domain hosts the Management Components of VMware Cloud Foundation system like Management vCenter Server, VI Workload Domains vCenter, SDDC Manager, and NSX Manager for all the Workload Domains. Minimum of four Nodes are required in Management Workload Domain.
- **VI Workload Domain**
  VI Workload Domain can also be referred to as Production Workload Domains as customer/tenant workload will be hosted in these workload domains. Minimum of three nodes are required in VI Workload Domain.
- **Horizon Workload Domain**
  Horizon Workload Domain automates deployment of VMware Horizon components which enables delivery of Virtual Desktop Infrastructure (VDI) and Remote Desktop Session Host desktops and applications.

This chapter will discuss VMware Cloud Foundations Architecture models along with other relevant topics related to architecture of VMware Cloud Foundations.

Standard Architecture Model

Standard Architecture Model is the preferred model of deployment and only model supported with VMware Cloud Foundations on VxRail. Standard Architecture Model has dedicated servers for Management Workload Domain and VI Workload Domain. This segregates Management Components of VCF from Tenant Workloads on Physical Layer as well. All domains – vCenter, NSX Manager, and Horizon View Management VM's – will reside on Management Workload Domain and Tenant Workload VM's/VDI's will reside on Tenant Workload Domain along with NSX-V Controllers in the case of NSX-V. Figure 1 shows examples of Standard Architecture Model.

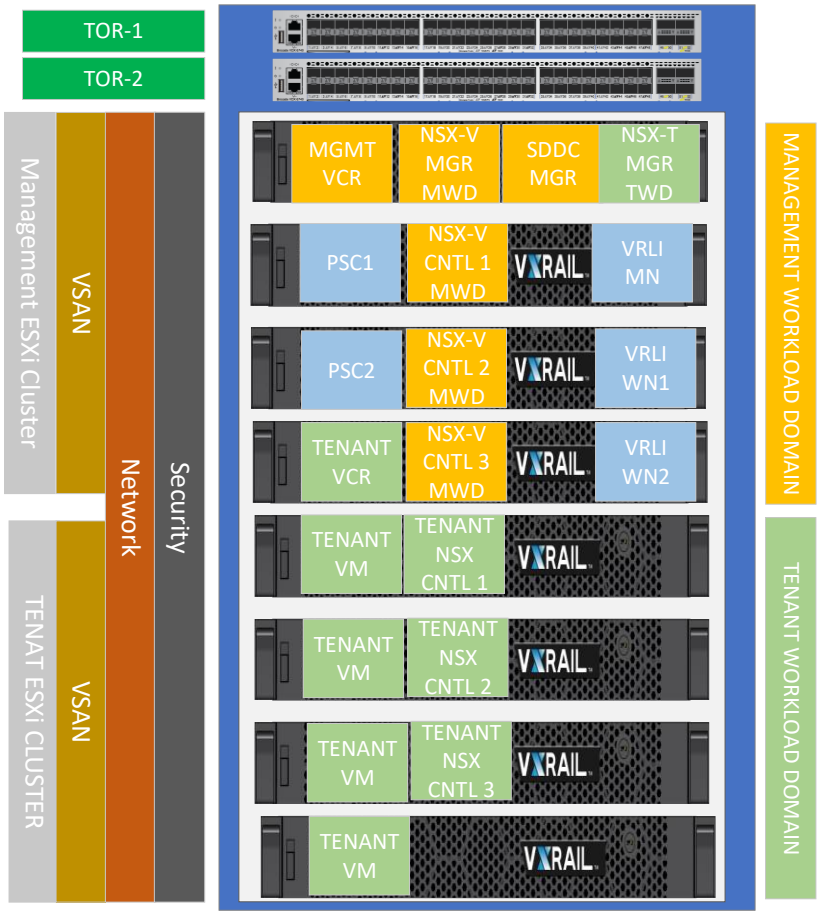


Figure 1

Figure 1 shows a single rack deployment with one Management Workload Domain with four Nodes and one Tenant Workload Domain with four Nodes. Minimum recommended nodes for Management Cluster are four.

In Management Workload Domain we have the following components deployed:

- Management Workload Domain vCenter
- Platform Service Controllers which server as a single sign on domain for Tenant vCenter Servers and Management Workload Domain vCenter Server.
- Tenant Workload Domain vCenter
- NSX-V Manager for Management Workload Domain
- NSX-V Controllers for Management Workload Domain
- NSX-T Manager for Tenant Workload Domain
- SDDC Manager
- vRealize Log Insight (Log Insight License for Management Workload Domain is included. Tenant Workload Domains can also be added with separate license)

In Tenant Workload Domain we have the following components deployed:

- Tenant Workload VM's

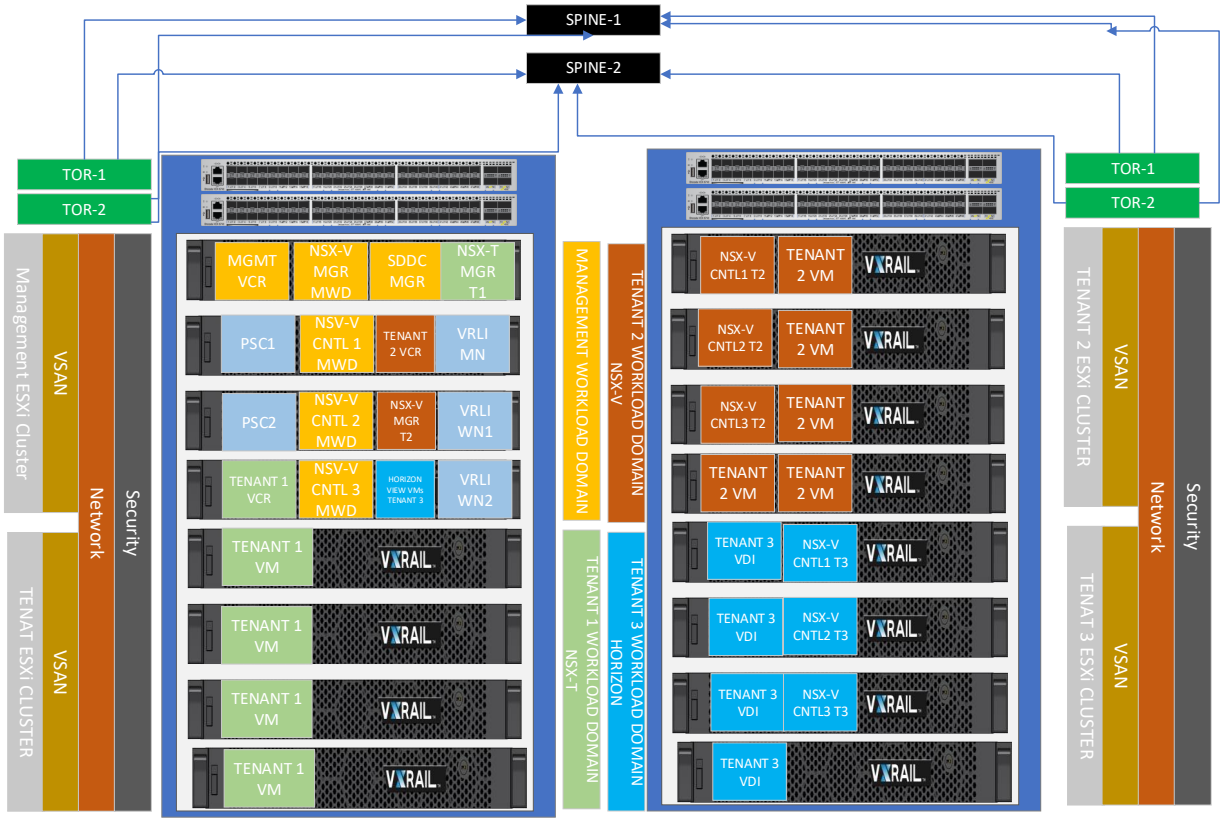


Figure 2

Figure 2 depicts a multi-rack deployment in Leaf Spine Network Topology where each rack has two Top of the Rack Switches, with each rack connecting to Spine Switches. Also in the above deployment we can see that we have one Management Workload Domain, one NSX-V Tenant Workload Domain, one NSX-T Tenant Workload Domain and one Horizon Workload Domain. This shows that multiple tenants with different configurations can be accommodated in a Single VMware Cloud Foundation Instance.

Management Workload Domain Components

- Management Workload Domain vCenter
- Platform Service Controllers which server as a single sign on domain for Tenant vCenter Servers and Management Workload Domain vCenter Server
- NSX-V Manager for Management Workload Domain
- NSX-V Controllers for Management Workload Domain
- SDDC Manager
- vRealize Log Insight (Log Insight License for Management Workload Domain is included. Tenant Workload Domains can also be added with separate license)
- Tenant 1 Workload Domain vCenter
- NSX-T Manager for Tenant Workload Domain 1
- Tenant 2 Workload Domain vCenter
- NSX-V Manager for Tenant Workload Domain 2
- Tenant 3 Workload Domain vCenter.
- NSX-V Manager for Tenant Workload Domain 3
- Horizon View VM's for Tenant Workload Domain 3 (Composers, Connection Servers, App Volume Managers, User Environment Manager, Unified Access Gateway, Load Balancers)

Tenant 1 Workload Domain Components

- Tenant Workload VM's

Tenant 2 Workload Domain Components

- Tenant Workload VM's
- NSX-V Controllers

Tenant 3 Workload Domain Components

- Tenant Workload VDI's
- NSX-V Controllers.

Consolidated Architecture Model

Consolidated Model is supported by VMware for smaller environments, i.e. less than six nodes. In Consolidated Deployment Model there is no segregation of physical hardware for Management Workload Domain and Tenant Workload Domain. All resources are shared by both Management Components and Tenant Workloads. Horizon and NSX-T are not supported with this model.

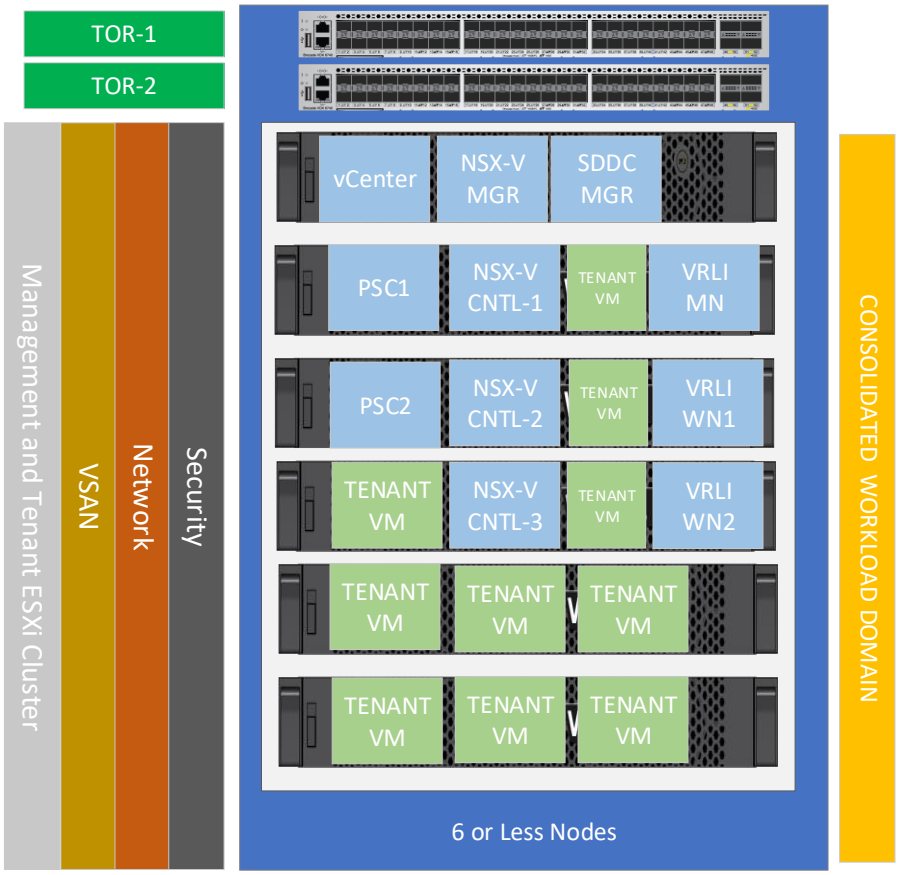


Figure 3

Figure 9 depicts a single ESXi Cluster with six Nodes with all the Management VM's as well as Tenant VM's. Single vCenter manages the environment and resource pools are used to provide isolation between management and tenant workloads. The environment is managed from a single vCenter Server and vSphere resource pools provide isolation between management and user workloads. Consolidate Architecture can be converted to Standard Deployment Model by adding nodes and creating a new Tenant Workload Domain followed by migration Tenant Workload VM's from Management Domain to New Tenant Workload Domain. This deployment model is not supported with VxRail.

Stretched vSAN Cluster with VMware Cloud Foundations

vSAN Stretched Cluster with VMware Cloud Foundation works similarly as a normal vSAN Stretched Cluster. With VMware Cloud Foundation we get the benefit of automated deployment of the Stretched Workload Domain and using NSX-V or NSX-T. With VCF on VxRail we recommend physical and logical configuration based on the VVD standardized architecture design which includes a Management Cluster (4 node cluster minimum) and Compute/Edge Workload Domain Cluster (4 node cluster minimum).

NSX-V Integration with VMware Cloud Foundation

With VMware Cloud Foundations we get the automated deployment of NSX-V. Whenever we deploy a new Workload Domain a new NSX-Manager Instance gets deployed on Management Workload Domain which is integrated with Tenant vCenter. 3-NSX Controllers get deployed on the Tenant Workload Domain. This way, as soon as the Workload Domain is deployed NSX-V is ready to use and VMware Validate Design (VVD) guidelines can be followed for deploying additional components.

NSX-T Integration with VMware Cloud Foundation

NSX-T components are deployed with the First NSX-T workload domain. It deploys three NSX-T Manager Virtual Machines in Management Workload Domain. Any further NSX-T workload domains created will share NSX-T Management resources already deployed. This way, as soon as the Workload Domain is deployed NSX-T is ready to use and VMware Validate Design (VVD) guidelines can be followed for deploying additional components.

VMware Validated Design with VMware Cloud Foundation

VMware Validated Design provides blueprints and guidelines for deploying a Software Defined Data Center. Similarly, VMware has VMware Validated Design for VMware Cloud Foundation which can be followed while deploying VCF on VxRail. Following VVD guidelines will reduce design flaws and increase efficiency. VMware regularly updates the guidelines. We can refer to https://docs.vmware.com/en/VMware-Validated-Design/index.html for more details.

VMware Enterprise PKS on VMware NSX-T Workload Domain

Kubernetes is a leading container orchestration system. Starting with VCF 3.8.1, we have the ability now to automate the deployment of VMware Enterprise PKS through SDDC Manager. Steps for automated deployment of VMware Enterprise PKS:

- We deploy the NSX-T workload domain using SDDC and configure NSX-T.
- Prepare the IP addresses and forward/reserve DNS records for the PKS API, Pivotal Operations Manager and the Harbor Registry (optional)
- Generate the certificates and private keys from a trusted certificate authority that include the fully qualified domain names for each PKS management component.
- Prepare the NSX-T Tier-0 router, node and pod IP blocks and a floating IP pool for Kubernetes cluster resources.
- Prepare the network settings and resources for the availability zones. This includes the network CIDR, gateway, reserved IP ranges, target logical switch and vSphere cluster for management and Kubernetes availability zone.

Once we have all these done, we use SDDC Manager for automated PKS Components deployment. Figure 4 represents a sample environment. VMware Enterprise PKS Control Plane VM's are automatically deployed.

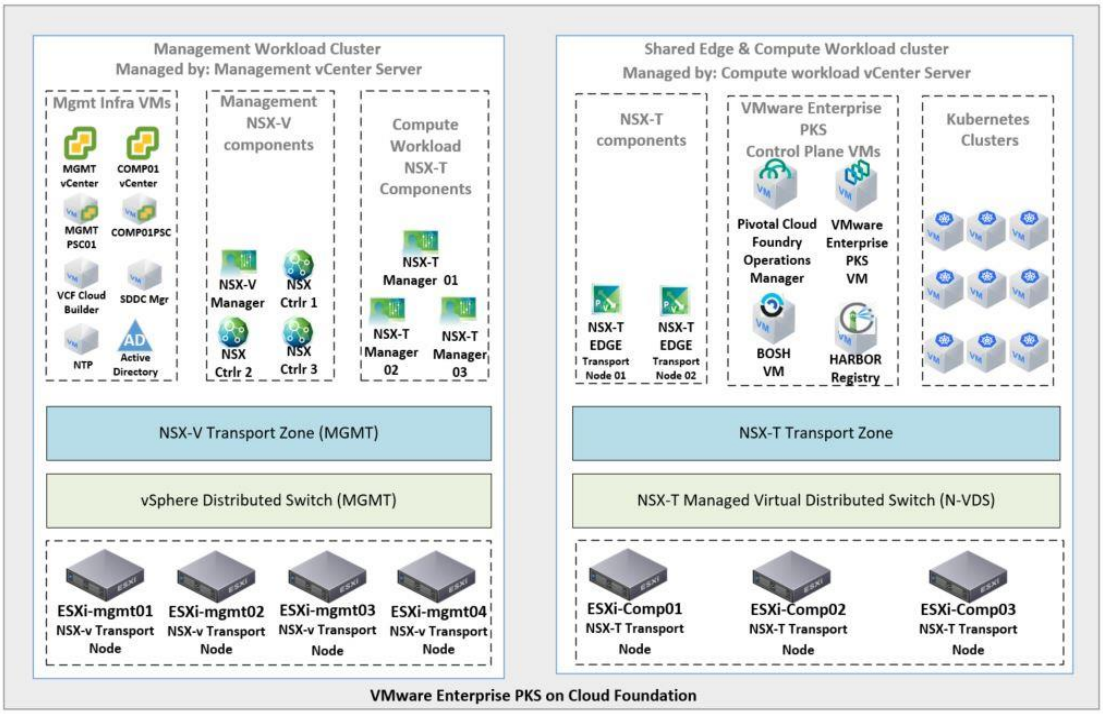


Figure 4

VMware Cloud Foundation Deployment Overview

Prepare Phsyical Infrastructure For Deployment	• Validate the Compatibility of ESXi Nodes as per VMware VCF Compatbility Matrix. • Rack , Stack and Cable the nodes. • Upgarde the Hardware Firmware Components . • Prepare ESXi Hosts. • Deploy Cloud Builder VM
Deploy VCF Cloud Builder VM.	• Download the VCF Cloud Builder Workbook. • Fill up the Environment Details in the workbook .
Upload the Workbook	• Upload the Cloud Builder Workbook • Validate the Environment
Begin the Automated Bringup of Management Workload Domain	• Using SDDC manager start Automated Bring Up of Management work load domain. • This will install SDDC Manager , vCenter , PSC, NSX Manager , NSX Controllers and Log Insight
Initiate Automated Compute Workload Domain Deployment as per requirements	• Once the Management Workload is deployed we can deploy Compute/Horizon/PKS workload Domain as and when required .
NSX-V Workload Domain	• If the deployed Tenant Workload Domain is NSX-V Compute Workload domain then SDDC Manager will deploy vCenter in Management Workload Domain , Deploy NSX Manager in Management workload Domain , Registerr NSX Manager with Tenant vCenter and Deploy 3 NSX Controller in Tennat Workload Domain.
NSX-V Horizon Workload Domain	• If we want to deploy Horizon Workload Domain then first we deploy a normal VI compute worklad domain and then use that compute workload domain to deploy SDDC VDI's. Horizon View Management VM's like Composers , Connection Servers, App Volume Managers, User Environment Manager , Unified Access Gateway , Load Balancers are deployed on Management Workload Domain. Also . There are some pre-requistes before deploying that should be met. We should refer VCF Administratior Guide for more details on this.
NSX-T VI Workload Domain	• The first NSX-T Workload Domain that we will deploy will lead to deployment of 3 NSX Managers on the Management Workload Domain. Any future NSX-T workload domains will also use the existing NSX-Managers.
VMware PKS Workload Domain	• We can deploy VMware PKS Workload Domain with NSX-T as defined in previous section .

Why VMware Cloud Foundation on VxRAIL

- Co-engineered with VMware and only VMware Co-engineered Solution available.
- Single point of contact for support-related issues.
- Proactive Dial Home Support.
- Automated end-to-end lifecycle management including automated VMware Components Upgrades along with VxRail Node Hardware firmware upgrades.
- Standardized on VMware SDDC Architecture.
- Tighter VxRail Integration within vSphere Client enables management of VxRail nodes from a single pane of glass.
- VxRail Software Bundles alignment with VMware Cloud Foundations Release.
- Dell Smart Fabric Integration for automation of Switch Configuration.
- Industry-Leading Compute Infrastructure.

Case Study

Engagement Background

African Airlines is the flag carrier of Ethiopia. Over the past seventy years, it has become one of the continent's leading carriers, unrivalled in Africa for efficiency and operational success, turning profits for nearly every year of its existence.

Operating at the forefront of technology, the airline has also become one of Ethiopia's major industries and a veritable institution in Africa. It commands a lion's share of the pan-African network including multiple daily east-west flights across the continent and currently serves 81 international destinations operating the newest and youngest fleets.

African Airlines' current vSphere infrastructure is based on IBM hardware acquired in 2014. The vSphere environment based on vSphere 6.5 has reached maximum capacity. The perception from African Airlines staff is that the current support is unreliable and costly. Currently, there is no disaster recovery plan in place to deal with a complete site failure. As a main driver for African Airlines' IT transformation strategy an agile approach that includes automation and self-service shall be adopted.

African Airlines engaged Dell Technologies to design and implement a new infrastructure to replace the current solution. The solution needs to address the current resource constraints and lacking site failover capabilities.

Conceptual Design

Initial design workshops with the project sponsors and all involved stakeholders of African Airlines defined their business goals along with their business requirements. In these meetings requirements, constraints, assumptions and risks (shown in the sections below) were also identified that influenced the design.

Business Requirements

Item	Design Quality	Description
R01	Scalability	Accommodate existing virtual machines in the new environment.
R02	Scalability	Account for 40% growth in the number of workloads based on the existing metrics.
R03	Availability	Design must provide a highly available solution to sustain operations during system failures.
R04	Availability	Design must provide failover capabilities to sustain two server failures at the same time.
R05	Availability	Service Level Agreement of 99.95% uptime per annum.
R06	Availability	Solution to span two data center in the main location and a second site within the same metro area.
R07	Recoverability	Recovery Time Objective (RTO) of 1 hours.
R08	Recoverability	Recovery Point Objective (RPO) of 30 minutes.
R09	Recoverability	Site failover capabilities for all virtual machines.
R10	Manageability	Management workload should be at least physically separated from production workload.
R11	Manageability	Automated upgrade and expansion processes must be in place.
R12	Security	Adopt software defined networking approach.
R13	Performance, Availability	The design must provide configuration parameters for best performance and resiliency.
R14	Manageability	Design must maintain simplicity where possible to allow existing operations teams to manage the new environments.
R15	Scalability	Solution should be able to be expanded at a later stage.

Design Assumptions

Item	Type	Description	Validated
A01	Infrastructure	DNS infrastructure is available including forward and reverse lookup for all vSphere components.	✓
A02	Infrastructure	NTP server is available for time synchronization of all vSphere components.	✓
A03	Infrastructure	Sufficient power, cooling and rack space is available to support the solution.	✓
A04	Security	African Airlines is responsible for creating all required certificates for the solution.	✓
A05	Operations	African Airlines has sufficient knowledge of how to manage the vSphere environment.	✓
A06	Network	Connectivity between sites in place.	✓
A07	Network	African Airlines is responsible for creating all VLANs that will be used in this solution at the core level as well as providing routing capabilities if required.	✓
A08	Implementation	African Airlines is responsible for assigning internal resources to assist during the implementation.	✓
A09	Network	IP address space is available for all components in this solution.	✓

Design Constraints

Item	Design Quality	Description
C01	Infrastructure	Reuse of current data center facilities.
C02	General	During normal operations no production workload should run in the DR site. Secondary site should only be utilized in a DR case.
C03	Infrastructure	Reuse of existing networking equipment.
C04	Recoverability	Avamar backup solution must be leveraged.
C05	Manageability	Integration into existing monitoring solutions - IBM Tivoli Monitoring for application monitoring, VMware vRealize Operations Manager for vSphere monitoring.

Resources are pooled together while adhering to the requirements and constraints of this design to run the workload. The environment is separated into management and production. Replication between sites is facilitating a complete site failover. All production VM on the current vSphere environment will be migrated onto the target solution as part of a migration project. Figure 5 illustrates the conceptual design of the environment.

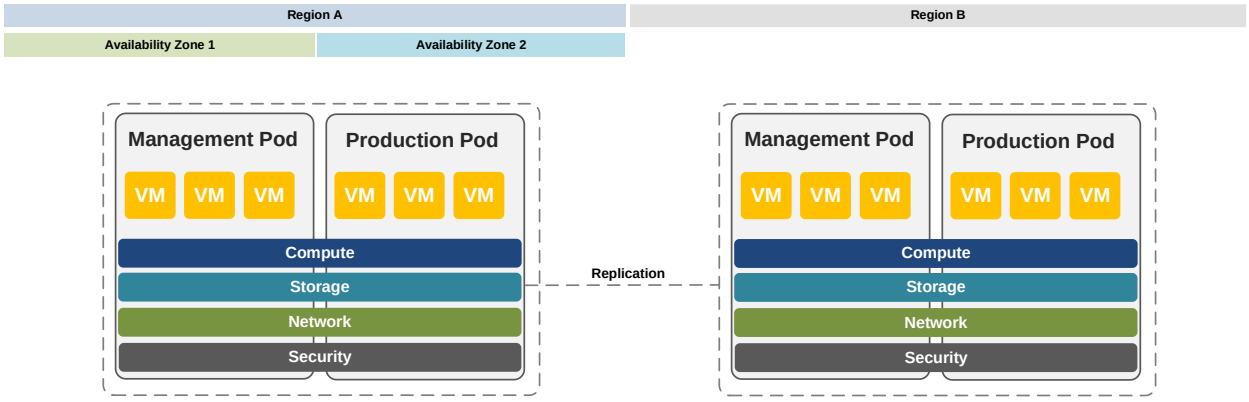


Figure 5

Overview - Logical Design

Decisions taken to translate African Airlines' conceptional design to a logical design.

Design Decision ID	DD01
Design Decision	Adopt VMware Cloud Foundation.
Design Justification	VMware Cloud Foundation provides an engineered framework to deploy a SDDC in a rapid way. VCF allows for automated lifecycle management of the full stack.

Design Decision ID	DD02
Design Decision	Use two availability zones in region 1 and region 2 as disaster recovery.
Design Justification	To achieve availability and recoverability requirements the solution will be deployed across multiple availability zones and regions. **Region 1:** Availability Zone 1: Stretched Cluster Availability Zone 2: Stretched Cluster **Region 2:** Individual Cluster

Design Decision ID	DD03
Design Decision	Create separate Workload Domain for management and production.
Design Justification	Separate production from production workload to comply with African Airlines business requirements and provides further scalability.

Design Decision ID	DD04
Design Decision	Use Hyperconverged nodes as standard building block.
Design Justification	Using vSAN ReadyNodes ensures seamless compatibility with vSAN at deployment, support and future expandability.

Design Decision ID	DD05
Design Decision	Use NSX as software defined networking solution.
Design Justification	Allow for transparent cross-region VM mobility, communication and micro segmentation.

Design Decision ID	DD06
Design Decision	Replication between regions will be used for disaster recovery.
Design Justification	Allow for seamless disaster recovery to comply with African Airlines' requirement.

Figure 6 outlines the logical design.

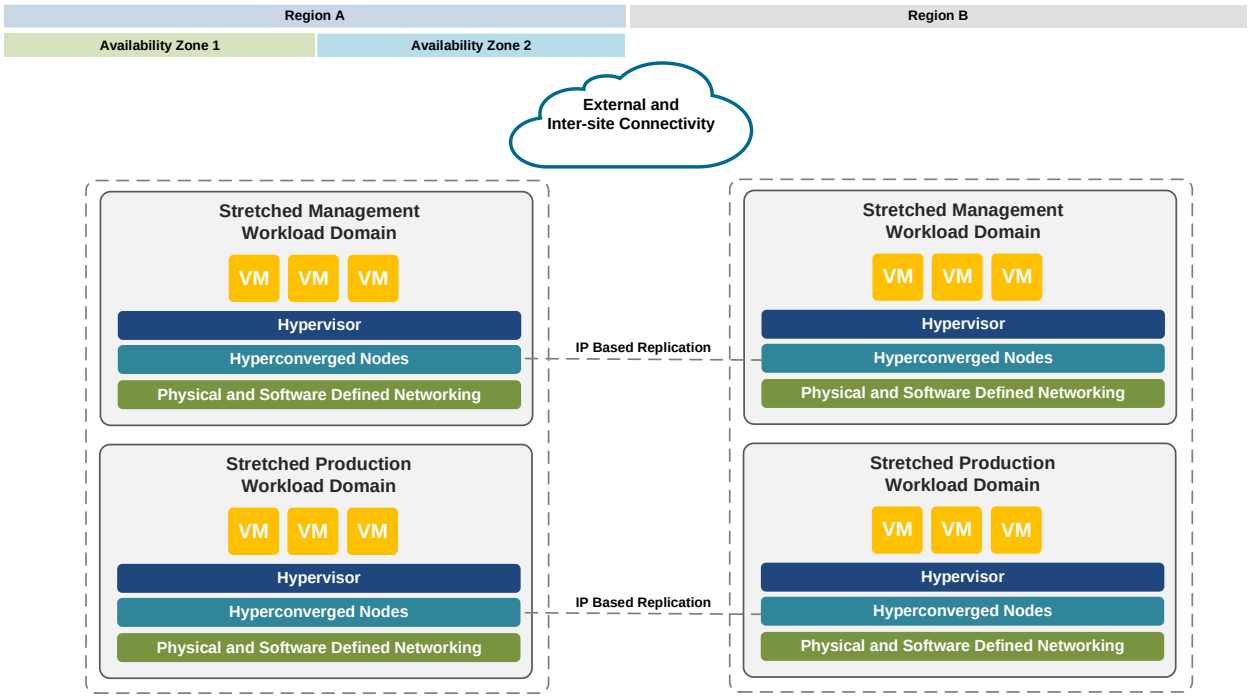


Figure 6

Overview - Physical Design

Sizing Rationale

The design needs to accommodate the workload running in the current virtual environment plus 40% growth. An assessment has been carried out to collect the required performance metrics to size the new solution accordingly. Data has been extracted from vCenter and RVTools over a period of one week in the current environment.

The following table summarizes the results of the analysis. It details the overall requirements for the vSphere environment to support the workloads of the existing workload. All values have been rounded up to ensure sufficient resources are available during peak times.

	Metric	Value
VMs	Number of VMs	196
CPU	Total number of vCPUs	631
	Average CPU usage in MHz	217085
	Peak CPU usage in MHz	409797
Memory	Allocated Memory in GB	1138
	Average Memory usage in GB	509

Storage	Allocated Virtual Disk space in TB	61
	Average IOs per second	10192
	Average throughput in Mbps	1176
	Peak throughput in Mbps	1872
Network	Average throughput in Mbps	982
	Peak throughput in Mbps	1421

A total of 40% growth needs to be accounted for in the environment based on the current resource usage. The table below lists the resource requirements including growth.

	Metric	Value
VMs	Number of VMs	274
CPU	Number of vCPUs	883
	Average CPU usage in MHz	303919
	Peak CPU usage in MHz	552715
Memory	Allocated Memory in GB	1898
	Average Memory usage in GB	712
Storage	Allocated Virtual Disk space in TB	85
	Average IOs per second	14269
	Average throughput in Mbps	1647
	Peak throughput in Mbps	2621
Network	Average throughput in Mbps	1375
	Peak throughput in Mbps	1989

Host Design

Design Decision ID	DD07
Design Decision	Use Dell AF-4 Ready Node as building block for the SDDC.
Design Justification	To account for the resource requirements, the following VSAN-ready nodes have been selected, while aligning to VMware recommendation in terms of sizing. **Region A:** Management Workload Domain AZ1: 4x AF-4 Nodes AZ2: 4x AF-4 Nodes Production Workload Domain AZ1: 12x AF-4 Nodes AZ2: 12x AF-4 Nodes **Region B:** Management Workload Domain 4x AF-4 Nodes Production Workload Domain 12x AF-4 Nodes

The table below outlines the individual node configuration per Workload Domain.

Management Workload Domain

Cores per Node	24
Memory per Node	128 GB
Capacity drives per Node	3x 3.84 TB SSD
Raw Cache per Node	900 GB SSD
Network Cards	4x 10 Gbit/s

Production Workload Domain

Cores per Node	24
Memory per Node	256 GB
Capacity drives per Node	3x 3.84 TB SSD
Raw Cache per Node	900 GB SSD
Network Cards	4x 10 Gbit/s

Figure 7 provides a visual overview of the host distribution.

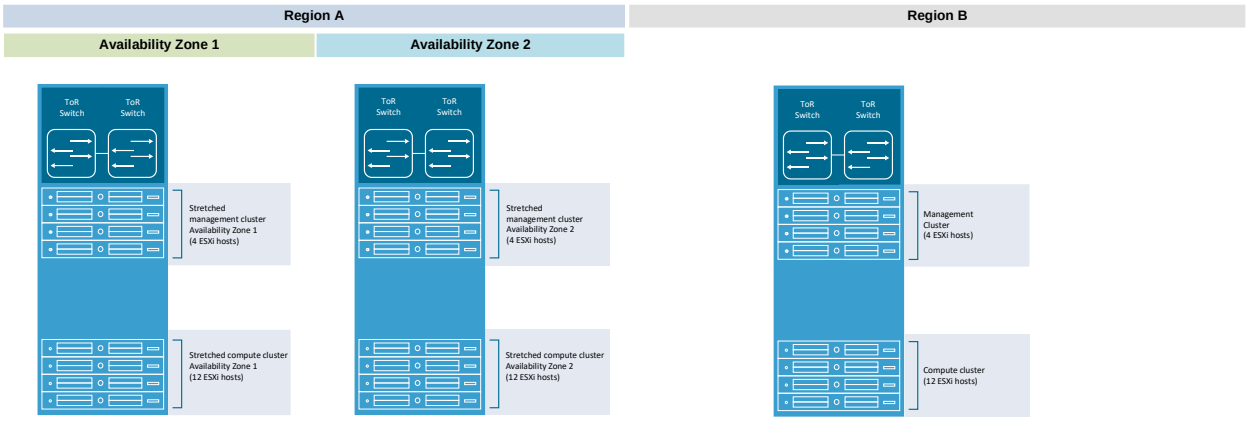


Figure 7

Network Design

Design Decision ID	DD08
Design Decision	Reuse existing Nexus 9236C switches.
Design Justification	Customer has an existing investment in Nexus 9236C switches that shall be reused. Each rack will include a pair of TOR switches. Each Hyperconverged node will be connected to each switch for redundancy.

Design Decision ID	DD09
Design Decision	NSX-v will be deployed in a multi-site configuration.
Design Justification	Allow for cross-site migrations and disaster recovery without the need to change any IP addressing.

Figure 8 provides an overview of the NSX architecture.

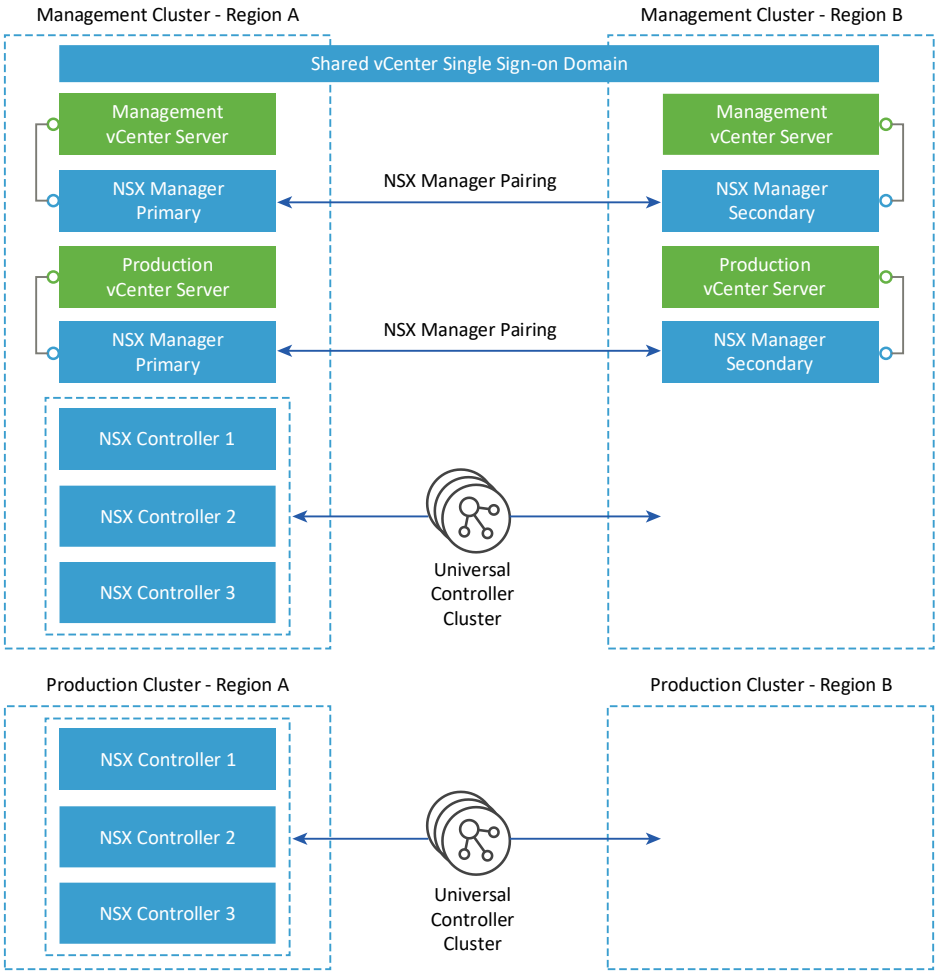


Figure 8

Disaster Recovery & Business Continuity

Design Decision ID	DD10
Design Decision	RecoverPoint for Virtual Machines will be used for Disaster Recovery.
Design Justification	Provide automated failover runbooks between both regions.

Figure 9 highlights the RecoverPoint for VM architecture.

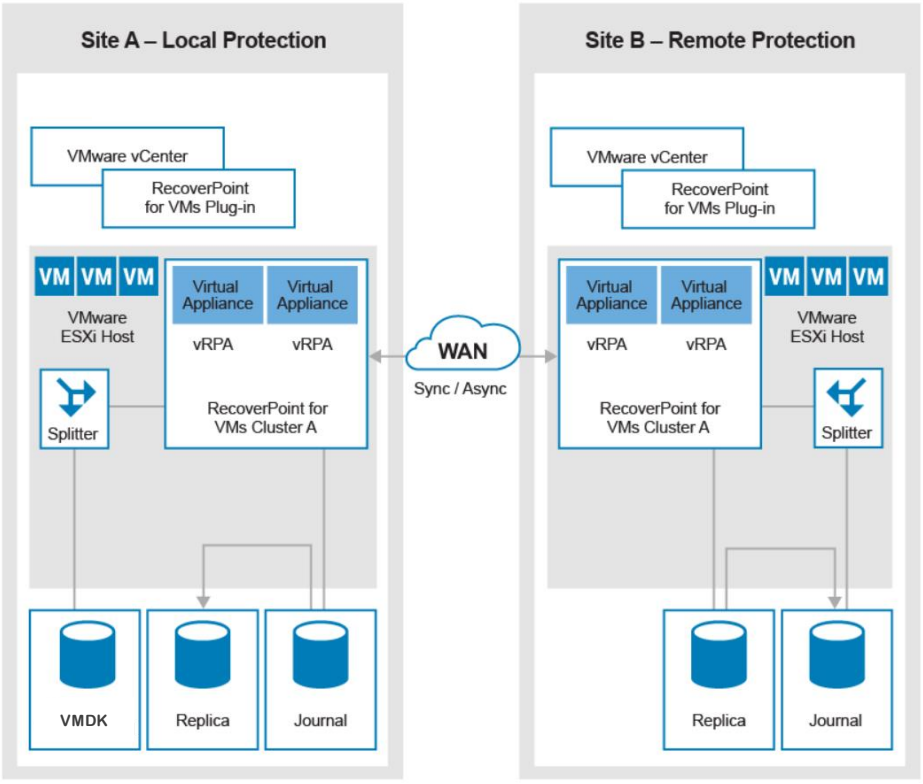


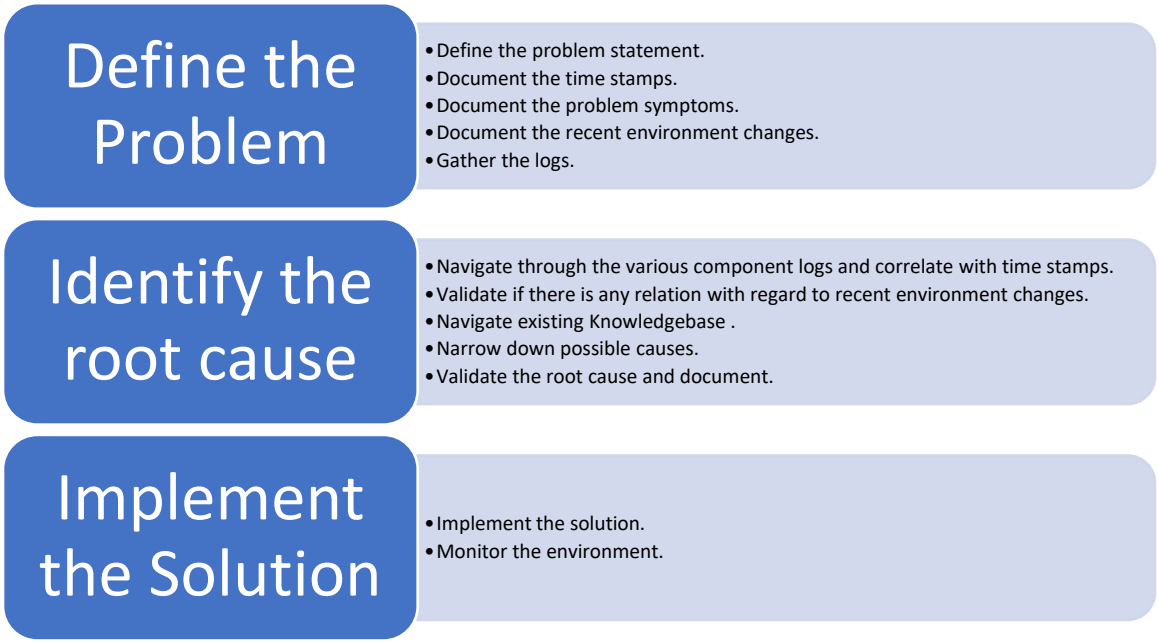
Figure 9

The table below provides an overview of business continuity and disaster recovery.

Component	Business Continuity	Disaster Recovery
Compute	Redundant physical components, vSphere HA	Hardware replacement, restore from config backup
Networking	Redundant physical components, NSX ICMP	Hardware replacement, Host profiles, restore from config backup
Storage	Redundant physical components and VSAN policies	Data replication, Hardware replacement, restore from VSAN
Data Center	Redundant power, cooling and backup generators	Site failover via RP4VM

Troubleshooting

As with VMware Cloud Foundations on VxRail we have virtualized Compute, Storage and Network along with Automation Layer. With so many abstraction layers troubleshooting becomes difficult. As per our experience we follow the approach below for troubleshooting issues and found it to be very helpful.



As VMware Cloud Foundations comprises many components we will highlight important log files that help us to troubleshoot issues related to environment. For individual components like vCenter, NSX, etc. we can refer to their respective log files.

Location	Purpose	Component
Logs\marvin Tomcat\logs\marvin.log	It's the main log for VxRail Operations.	VxRail Manager VM
/opt/vmware/bringup/logs/vcf-bringup.log /opt/vmware/bringup/logs/vcf-bringup-debug.log	It's the main log for SDDC Manager Workload Domain operations.	SDDC Manager VM/Cloud Foundation Builder VM
/var/log/vmware/vcf/bringup/vcf-bringup-debug.log	Log to be referred to for bringing up tasks.	SDDC Manager VM
/var/log/vmware/vcf/lcm	Logs related to VMware Cloud Foundation Component Upgrades.	SDDC Manager VM

VMware Cloud Foundations includes very helpful Supportablity and Serviceability (SoS) CLI utility. This utility can be used for log bundle collection, detailed health checks and other maintenance related tasks. Location of the utility is /opt/vmware/sddc-support/sos on SDDC Manager VM.

Examples of the utility

./sos –log-dir /tmp –domain-name MGMT –sddc-manager-logs

Above command will collect SDDC Manager logs along with VxRail Manager Logs.

./sos - - health-check

Above command will perform detailed health check of the environment.

sos –help

Above command will display all the available command options.

We also have an important command to see the password of the environment. Below command needs to be run from SDDC Manager.

/use/bin/lookup_password

References

https://docs.vmware.com/en/VMware-Cloud-Foundation/