VMware Tanzu Architecture for Dell EMC VxRail

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Executive Summary
VMware Tanzu Architecture for Dell EMC VxRail (TA4V) is an integrated environment built on hyperconverged hardware/software infrastructure. It offers you high performance potential, convenience, and it addresses the challenges of creating, testing, and updating applications in a consolidated production environment. This describes a set of validated architectures anyone can adopt to get proven operational benefits. The architectures are organized to provide a pathway for growing your environment from a minimal single cluster system to a multiple cluster architecture.

Key Benefits
TA4V enables you to quickly and reliably create an integrated application deployment platform and provides a variety of platform sizes to meet your needs. It is a validated set of architectures that recommends the scalable, hyper-converged Dell EMC VxRail Appliance along with VMware vSphere, VMware vSAN and NSX-T Data Center products. With TA4V, you can deploy production-ready application container environments quickly and reliably compared to a build-it-yourself approach.

Several application container technologies such as TKGI and TAS, are designed to meet application operational needs. Professional Services engagements from Dell EMC and VMware can help you install and test TA4V in your IT environment. Your IT professionals who are tasked with planning compute, network, and storage capacity can work with Dell EMC Professional Services to determine the requirements for these resources.

TA4V enables developers to quickly publish, run, and scale legacy software, packaged software, and cloud-native applications. The TA4V platform is based on an integrated infrastructure that enables IT operators to easily manage and scale the development environment with tools such as VxRail Manager and Tanzu Operations Manager.

With TA4V, your organization will benefit from:
- Reference architectures for a variety of highly available Tanzu application platforms
- Private cloud and infrastructure services with simplified deployment
- Highly available platforms on which to develop and quickly deploy applications, and which reduce application delivery times
- Modern developer platforms that boost developer productivity by combining application services, service discovery, container management, and orchestration within an ecosystem of developer tool plug-ins
- Consistent cloud solutions, providing increased reliability, portability, and agility
- Lifecycle management from the lowest level hardware system firmware to the highest level of application container deployment system of choice

Versions and Bill of Materials
Validated Versions And Interoperability For This Release

This recommended architecture includes VMware vSphere and NSX-T Data Center, a software-defined network virtualization technology that runs on VMware ESXi hosts and combines routing, firewalls, NAT/SNAT, and load balancing. It also includes an application container layer from several choices available in the VMware Tanzu portfolio.

Supported Software Components For Interoperability

<table>
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<tr>
<th>Software Component</th>
<th>Version</th>
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<tr>
<td>VMware vSphere ESXi</td>
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<td>VMware NSX-T Data Center</td>
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<td>VMware NSX-T Container Plug-in (NCP)</td>
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<td>Operations Manager</td>
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<td>VMware Tanzu Kubernetes Grid Integrated (TKGI)</td>
<td>1.11.latest</td>
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<td>Tanzu Application Service (TAS) for VMs</td>
<td>2.11.latest</td>
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<tr>
<td>VMware Harbor Registry</td>
<td>2.2.latest</td>
</tr>
<tr>
<td>S3 Compatible Storage</td>
<td>v4</td>
</tr>
</tbody>
</table>

To use all the features listed here, NSX-T Data Center requires at least Advanced licensing from VMware when used with TAS for VMs. The equivalent of that licensing is included with TKGI.

The following Bill of Materials (BOM) along with sample applications, was used to validate a running platform. These components were selected as broadly representative of common customer installations.

Lab Validated Components BOM

<table>
<thead>
<tr>
<th>Component</th>
<th>Version or Model</th>
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<td>VxRail BIOS</td>
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<td>VxRail CPU (x2)</td>
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<td>VxRail NIC</td>
<td>Intel® 10GbE 4P X710 rNDC 4 port (only 2 used)</td>
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<td>VxRail RAM (x12) per</td>
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<td>Flash Storage (Cache/Capacity)</td>
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<td>VMware NSX-T Data Center</td>
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<td>VMware NSX-T Container Plug-in (NCP)</td>
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Minimal Viable Platform

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Starter Kit Applied to TAS for VMs or TKGI

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Starting small is a great way to establish a container-ready infrastructure. You can read more about each of the key components in subsequent chapters but at this point we introduce the smallest single configuration recommended for getting started. This configuration is validated as stable and functional for timed trials, proofs-of-concept, small, non-production-grade application deployments requiring only host level fault tolerance, or for remote/branch office operation.

Starter Kit Applied to TAS for VMs or TKGI

Starter Kit Applied to TAS for VMs
Starter Kit Applied to TKGI

View a larger version of this diagram.
This configuration includes the following key components:

- VxRail Appliances in a four node configuration
- VxRail HCI System Software deployed for server firmware and vSphere provisioning
- Leaf-Spine switching in a redundant configuration (not shown)
- vSAN storage configured as sole storage target
- Application container platform of choice, either Tanzu Application Platform (TAS) for VMs or Tanzu Kubernetes Grid-integrated (TKGI)
- NSX-T Data Center network virtualization and security platform for either TAS, TKGI or both
- Host groups as needed to organize components for high availability
The following trade-offs have been made in the Starter Kit platform including:

- Overall capacity for applications is shared with the management infrastructure
- Management and operational components are kept to a minimum to reduce waste and speed recovery after a failure event
- Storage is purposely kept simple for stable operation during service outages, patching or unplanned outages
- A maximum of a single host can be out of service at any one time in order to maintain normal operations

Also, consider that vSphere Dynamic Resource Scheduling (DRS) can be applied to steer VMs either apart from each other (anti-affinity) or towards each other (affinity). DRS can be used to keep redundant services (e.g. Gorouters) apart in order to facilitate survivability during an outage.

**Note about DRS rules:** When using DRS, we recommend using the “should” rule vs the “must” rule. This will allow VMs that violate the DRS rule to power on anyway as opposed to being denied power on. For example, you have three AZs and eleven Gorouters. With a DRS anti-affinity “should” rule they will deploy on each server separately and then overlap but all power on. With the “must” rule, only four will power on and the others will not, as they can not be placed on a server away from the others.

The next steps of system growth will be discussed in subsequent chapters.
Primary Technical Concepts

In this topic

Dell EMC VxRail and VMware vSphere
VMware NSX-T Data Center Software Defined Networking
Architecture Review

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Dell EMC VxRail and VMware vSphere

TA4V is based on VxRail hyper-converged infrastructure (HCI) hardware from Dell EMC. A hyper-converged solution is made up of servers, network switches and management software to create a complete set of data center resources in a single, collapsed system. There is no need to separate storage systems from network systems from compute systems. The VxRail solution includes tools to organize servers into clusters of virtualized compute capacity, establish and format a shared storage target from individual drives in servers and align the networking ports to the needed jobs, all through automation.

Further, VxRail establishes a lifecycle management system to keep the clusters hardware patched, current with VMware releases through further automation.

Overall, the purview of VxRail HCI System Software is to take servers in a raw state and deliver a fully paved vSphere installation, complete with vCenter Server management cluster(s), vSAN shared storage and related constructs.

VMware NSX-T Data Center Software Defined Networking

Virtualized, software-defined networking is a core concept leveraged by the TA4V solution. This important infrastructure layer brings maximum flexibility and growth potential to TA4V. You can transform a small system into a large system without having to rebuild the entire platform.

NSX-T Data Center brings many important capabilities to the platform. For example, you will benefit from:

- Tunneled networks of near-infinite capacity for Orgs, Namespaces and Apps to use
- Bridged interfaces to the datacenter network core that can be expanded and clustered for speed, capacity and redundancy
- Routing interfaces that are defined and deployed logically for a variety of needs to meet Org, Namespace and App needs, including routing directly to application containers
- Load balancing logical instances for Apps and Namespaces on-demand

The Enterprise PKS software has native support for NSX-T Data Center built into the product and requires an NSX-T Data Center installation to be completed prior to use. TAS for VMs software is also compatible with NSX-T Data Center but does not strictly require its presence.

Architecture Review

The overall architecture of TA4V is as follows (bottom up view):

- A VxRail HCI cluster, or series of clusters, are organized using VxRail Manager
- vSphere is paved into cluster(s) via VxRail Manager
• A vSAN shared storage target in every cluster is created from local disks of every server in the cluster
• NSX-T Data Center is layered on and a routed interface to the datacenter is established
• The container platform of choice is layered onto the compute cluster(s) and interfaced with NSX-T Data Center for dynamic deployment of networks, routers and load balancers

All of these components work together to establish a horizontally-scalable (via adding hosts to a cluster) and vertically-scalable (via adding memory/disk/network to cluster hosts) container-ready system that is self-contained and self-healing.
Growth Beyond Minimal Viable Platform

In this topic

Single Cluster Stretched Across Three Racks
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TKGI Multiple Cluster Design

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Organic growth from the Minimal Viable Platform (MVP) to a more complex system is expected and encouraged. The next sections will offer recommendations on transforming to higher levels of fault tolerant architectures.

Single Cluster Stretched Across Three Racks
This second stage design (MVP2) improves upon the capacity of the system and the resiliency of the storage system.

**Key items that change are:**

- Two more physical racks are added bringing the starter kit system into a three rack, three availability zone (AZ) configuration.

The maximum number of hosts per cluster for this architecture increases from 64 hosts to 192 hosts and increases the maximum number of powered-on VMs to 40,000.

**Unchanged items as compared to MVP:**

- Management functions do not change location
By transforming into a three rack configuration, several HA features from different parts of the configuration align. Each pair of hosts in a rack can be designated a vSAN fault domain. If your vSAN cluster spans across multiple racks or blade server chassis, you can use Fault Domains to protect shared storage against rack or chassis failure. With fault domains, when you add one or more hosts to each fault domain you increase the high availability of shared storage which is a key contributor to improved platform resiliency. This shared storage HA solution is a significant improvement.

vSphere Host Groups are defined which align to the three racks of hosts which then comprise three Availability Zones. These Availability Zones are then exploited by TAS for VMs and TKGI to improve resiliency. The Host Groups feature is a great way to pin the application containers resource usage to an aggregation of computing power and memory that is cluster-aligned without having to manually balance the entire cluster. This is akin to using Resource Pools in the cluster but without having to sub-segment the available computing power and memory using shares.

If the intent is to dedicate the entire installation to application containers, then Host Groups are less valuable as you can just set the entire cluster as an AZ. But, if there is the desire to blend application containers with any other kind of workload, even two different kinds of application container technologies at once, Host Groups fit well to segment capacity without the constraint of resource shares.

Migration from the single rack architecture to using three racks is easy to complete with TAS for VMs by modifying vSphere host group definitions and performing a `bosh recreate` operation. The PaaS will deploy all non-singleton components evenly across all AZs as long as the instance count of a given component is evenly divisible by the number of AZs. We recommend that you review and adjust the number of non-singleton components defined to achieve the resiliency you need. For example, review the number of Gorouters you are running, and use a count evenly divisible by the number of AZs you have defined, three in this model.
This third stage design (MVP3) is production-ready with ample high availability and redundant capacity for full-time Enterprise use. This size is appropriate for combined TKGI and TAS for VMs deployments. If required, you may use host groups (or Resource Pools with or without host groups) to organize components within the clusters capacity. There is no practical reason to scale horizontally (more clusters/AZs) from this model as the upper limits of aggregate compute & memory far exceed the capability of the software components that make it up. If true exascale capacity is desired, a better approach is to deploy three of these models in parallel as opposed to one, bigger one.

**Key items that change are:**

- High Availability (HA) of the IaaS layer is significantly improved with the addition of new vSAN domains and increased host capacity.
- High Availability (HA) of the PaaS layer is improved with a separation of management functions from applications and a stronger alignment of PaaS HA (AZs) to IaaS HA constructs, including vSphere HA and vSAN fault tolerance.
- A new cluster is deployed strictly for management functions, isolating them for resource use/abuse in the application clusters and also isolating the HA that supports them.
- A second and third application cluster are deployed (for a total of four clusters) resulting in three clusters dedicated for applications.
All non-singleton PaaS components are deployed in multiples of three to take advantage of three Availability Zones. HA features of both the IaaS and PaaS are aligned and operating in the AZs.

Migration from the MVP1 model to this multi-cluster architecture directly will be a challenge, as all management VMs from vSphere, NSX-T Data Center and PaaS will be migrated to a dedicated cluster and not blended in with any of the application containers running on TKGI and TAS for VMs. A fresh installation of the PaaS layer (at least) makes this model the easiest to install, as it will give you the opportunity to place management components in the management cluster and evacuate any pre-existing clusters of anything other than application components.

Migrating from the Single Cluster/Three Racks (MVP2) model to this one will also include challenges with relocating management functions from the application cluster to the new management cluster. This can be accomplished as long as there are shared networks and storage between the current management cluster and the new management cluster. The new management cluster should be built so that you can use vMotion and storage-vMotion to migrate objects to the new management cluster. Or, a consolidation of all management functions onto a single rack's hosts prior to addition of new capacity could be accomplished. The approach is to evacuate all management functions from the existing racks targeted for applications in favor of placement on the new management cluster. How best to accomplish this is dependent upon the architecture of your current environment.

TKGI Multiple Cluster Design
VMware Tanzlu Architecture for Dell EMC VxRail
Tanzu Kubernetes Grid - integrated
Reference Architecture

View a larger version of this diagram.
Storage

In this topic

Kubernetes Storage Considerations (TKGI Storage)
Cloud Foundry Storage Considerations (TAS for VMs Storage)
TAS for VMs Blobstore Options
  Elastic Cloud Storage
  Virtustream Storage Cloud
  Internal Blobstore

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Kubernetes Storage Considerations (TKGI Storage)

TKGI can be used to manage multiple Kubernetes clusters distributed across multiple vSphere clusters. Each Kubernetes cluster’s storage requirements are determined from the applications planned but are limited by the size of the cluster. Detailed guidance on how to configure and manage storage can be found in the TKGI Documentation.

The VxRail servers used in TA4V include vSAN, which is well suited to TKGI needs on a per vSphere cluster basis, or in the stretched cluster approach (MVP2) using vSAN Fault Domains. This will provide storage for the TKGI installation in each AZ. But you may need storage for stateful applications. You cannot look to vSAN to satisfy the storage needs for cross-cluster common storage.

TKGI storage options to support stateful apps include:

- NFS
- iSCSI connected datastores
- Fiber Channel connected datastores

In order to use external connected datastores across all clusters, each cluster must be connected separately.

vSAN does not support sharing datastores across vSphere clusters. As fail-over across availability zones is desired in the multiple cluster architecture, deploying external shared storage across those vSphere clusters / availability zones such as NFS/iSCSI/FC for both static and dynamic persistent volume provisioning for stateful workloads is recommended. Please refer to TKGI Documentation for the implementation details of persistent volumes.

In summary: You must provide a shared storage target for TKGI to use across all clusters in use for stateful apps that can not be a cluster’s vSAN, unless there is only one cluster used by TKGI, or shared storage is not drawn from vSAN, or no stateful applications can be deployed.

Cloud Foundry Storage Considerations (TAS for VMs Storage)

VMware recommends the following capacity allocation for TAS for VMs installations:

- For production use, at least 8 TB of available capacity, either as one 8 TB store or a number of smaller volumes adding up to 8 TB.
  High churn or heavily used development foundations may require significantly more storage to accommodate new code and buildpacks. A “development” PaaS installation will see significantly higher storage consumption than a “production” one due to rapid app prototyping and blob creation.
- For small installations without many tiles, 4-6 TB may suffice.
The primary consumer of storage is the NFS/WebDAV blobstore included in TAS for VMs. This job can be externalized to a hardware or emulated software S3-compatible blob store (see below).

- Do not use the included TAS for VMs blob store VM in any production PaaS Foundation.

TAS for VMs Blobstore Options

Elastic Cloud Storage

Dell EMC ECS object storage features a flexible software-defined architecture that provides the simplistic benefits of the public cloud without the risk, compliance, and data sovereignty concerns.

TA4V can use the ECS platform as its blobstore location to store application code, buildpacks, and applications. The blobstore uses the S3 protocol and can be managed by ECS nodes. The ECS platform provides software-defined object storage that is designed for modern cloud-scale storage requirements.

With Dell EMC ECS, VMware recommends that you use unversioned buckets for file storage by clearing the Use versioning for backup and restore checkbox in the File Storage pane of the TAS for VMs tile. For information, see Step 3: Configure PAS File Storage in this Dell EMC ECS whitepaper. You can use mirroring as an alternative to versioning.

Virtustream Storage Cloud

Virtustream Storage Cloud is a hyper-scale, enterprise-class, public cloud object storage platform, built for resiliency and performance. Virtustream provides a unique value proposition with enterprise-class off-premises primary and backup storage.

Internal Blobstore

TAS for VMs provides an internal WebDAV blobstore that can be used to store persistent data. The TAS for VMs internal blobstore is deployed as a single virtual machine in TAS for VMs. It does not offer high availability but can be backed up using BOSH Backup and Restore (BBR). It is designed for small, non-production deployments. For TAS for VMs production-level deployments, Dell EMC and VMware recommend using an external S3-compatible blobstore.
Routing

In this topic

- NSX-T Data Center Edge Type and Load Balancer capacity planning
- TKGI NSX-T Container Plugin for ingress traffic
- Ingress Controller and Load Balancing for TKGI
  - Layer 7 Approach Using Ingress Controller
  - Layer 4 Approach Using LoadBalancer Service

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NSX-T Data Center Edge Type and Load Balancer capacity planning

It is recommended that you have a minimum of four large Edge VMs in a configuration of two active-standby pairs (at least two instances are necessary for HA) which should be considered as the minimum for load balancing. A production grade deployment should only use large load balancers.

The type of Edge deployment is up to you based upon your application needs and system capacity. Edges as VMs offers maximum flexibility but uses resources of the cluster. Bare metal Edges perform much better than Edges in VMs. Since T4A is a "hyperconverged" or "collapsed" model, the approach of using VMs for Edges is an easy place to start. Though VMware recommends starting with Edges as VMs, you may discover that, at some point, edge capacity will become saturated. Then you will want to add or replace them with bare-metal Edges for more capacity as necessary.

Introduced in NSX-T 2.5, users can assign edges to defined fault domains. When TKGI provisions load balancing T1 routers, the active and passive edges are assigned on separate zones automatically, which increases the resiliency.

The size of the load balancer determines the number of Virtual Servers, Pools, and Pool Members per LB instance. Learn more about configuration maximums at VMware’s Configuration Maximums site.

Important Note: Since TAS for VMs and TKGI use active/standby Edge Node Load Balancer Services, you will need to consider capacity per Edge pair to derive the available number of Load Balancer Services you will need. Put another way, for each pair of Edge servers, the Load Balancer Service capacity is equivalent to just one edge instance since the other is treated as stand-by.

The number of available Load Balancer instances is directly proportional (1:1) to the maximum number of Kubernetes clusters that can be supported. Each Kubernetes cluster would use a minimum of one load balancer from an active Edge instance. Based on the type of load balancer and the Edge, the load balancer instances are fixed. As such, the resulting number of Kubernetes clusters created on the edge are also constrained by the number of free loadbalancer services on the active Edge.

Note: Maximum number of Edge nodes per Edge Cluster is 10 (as of NSX-T Data Center 2.5). If the required number of Edge nodes is greater than 10, you will have to create additional Edge clusters. If the Load Balancer service capacity is fully utilized on a given Edge pair, then install and bring up additional Edge VM instance pairs in the same Edge Cluster to handle requirements for additional load balancers (for existing or new TKGI clusters).

Learn more about configuration maximums at VMware’s Configuration Maximums site.

TKGI NSX-T Container Plugin for ingress traffic

There is no native way to reach the apps you will run in TKGI unless you deploy one of the following. What you select influences load balancing choices. Kubernetes has three ways for external users to access services running in a Kubernetes cluster:
The NSX-T Load Balancer supports both layer 4 and layer 7 ingress traffic, as well as SSL encryption.

The TKGI NSX-T container plugin (TKGI NCP) integrates with NSX-T Load Balancer. The Kubernetes operator can interface with Kubernetes resources (ingress controller and load balancer) to provision and configure an NSX-T Load Balancer.

The Benefits of TKGI NCP + NSX-T integration:

- Kubernetes users only need to manage Kubernetes resources rather than lower level network infrastructure
- NSX-T Load Balancer provisioning and configuration automatically occurs and includes the following:
  - Performs IP assignment (from pre-assigned IP Pool)
  - Configures the routing rules between the Load balancer and the Kubernetes pods
  - Configures SSL encryption/decryption

You have a choice selecting a layer 4 or layer 7 approach based upon the type of application traffic you have. A layer 4 approach is a good choice for TCP-bound traffic types. A layer 7 approach is best for HTTP-bound traffic types. Each will be described here.

Ingress Controller and Load Balancing for TKGI

Layer 7 Approach Using Ingress Controller

Domain info for ingress is defined in the manifest of the Kubernetes deployment. Here is an example.
Layer 4 Approach Using LoadBalancer Service

When pushing a Kubernetes service with type set to `LoadBalancer`, NSX-T Data Center automatically creates a new virtual IP (VIP) for the service on the existing load balancer for that namespace. You will need to specify a listening and translation port in the service, along with a name for tagging. You will also specify a protocol to use. Here is an example.

```yaml
apiVersion: v1
kind: Service
metadata:
  ...
spec:
type: LoadBalancer
ports:
  - port: 80
targetPort: 8080
protocol: TCP
name: web
```
Summary

VMware Tanzu Architecture for Dell EMC VxRail is a carefully considered, fully inclusive and regularly validated approach to using appropriate hardware and software elements to produce a highly scalable PaaS installation for today and into the future as you grow your system. The maturity path to follow starts with a minimally viable, low cost platform that features all the capability needed for small and remote installations and concludes with an Enterprise-grade, full scale and expandable system that can be grown and upgraded over time without re-architecture. These models can be used and reused over and over around the business as needs arise. You can use these with confidence, as each edition has been fully tested on real world, full scale hardware exactly as described. You can be confident that it will operate as described. Each validation cycle tests the target platform for functionality and performance.

TAS for VMs and TKGI Installation

A fully meshed TKGI and TAS for VMs installation based on best practices and reference design considerations will look as follows:
The common elements of these two platform technologies are the NSX T0 router and the associated T1 routers. This approach allows for any possible cross traffic between TKGI and TAS for VMs applications to stay within the bounds of the T0 router. Cross traffic does not need to exit the NSX overlay. This also provides a convenient, singular access point to the whole installation, making deployments of multiple, identical installations easier to automate.

Further Considerations

With a single vSphere Cluster, the Host Groups feature introduced in Ops Manager v2.7 can be used in conjunction with Resource Pools in vSphere Clusters as AZ constructs to stack different installations of PaaS. Host Groups provide a way to pin hardware resources to an AZ. Resource Pools provides a way to aggregate host resources.

As server capacity continues to increase, the efficiency of deploying independent clusters of a server just for one installation of one product is low. As customers are commonly deploying servers approaching 1 terabyte of RAM, stacking many installations in these clusters improves overall resource utilization.

You may be tempted to split the TAS for VMs and TKGI installations into separate network parent/child configurations, behind separate
T0 routers. Before doing this, review VMware’s best practices for T0 to T0 routing efficiencies and weaknesses to ensure that the approach meets your needs.
Tanzu Architecture for Dell EMC VxRail Release Notes

In this topic

3.2.0

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3.2.0

Release Date: September 9, 2021

- Bill of materials update since VMware Tanzu™ Architecture for Dell EMC VxRail v3.1
  - VxRail 7.0.132 -> 7.0.202
  - NSX-T 3.1.0 -> 3.1.3
  - Ops Manager 2.10
  - Tanzu Application Service for VMs 2.10 -> 2.11
  - VMware NSX-T Container Plug-in for TAS 3.1.0 -> 3.1.2
  - Tanzu Kubernetes Grid Integrated (VMware Enterprise PKS) 1.10.0 -> 1.11.2
  - VMware Harbor Registry 2.1.3 -> 2.2.2

- NSX-T 3.1.3 Release Notes
- Tanzu Kubernetes Grid Integrated (VMware Enterprise PKS) 1.11.2 Release Notes