Dell PowerFlex Rack with PowerFlex 4.x

Architecture Overview

May 2024
Rev. 3.0

DELL Technologies

Notes, cautions, and warnings

NOTE: A NOTE indicates important information that helps you make better use of your product.

CAUTION: A CAUTION indicates either potential damage to hardware or loss of data and tells you how to avoid the problem.

WARNING: A WARNING indicates a potential for property damage, personal injury, or death.

Contents

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Introduction

The *Dell PowerFlex Rack with PowerFlex 4.x Architecture Overview* describes the high-level design of PowerFlex rack.

The target audience for this document includes customers, sales engineers, field consultants, and advanced services specialists who want to deploy a high-performance, scalable, and flexible infrastructure using PowerFlex rack.

PowerFlex rack is a fully engineered rack-scale system with integrated networking and professional white glove deployment and single call support. PowerFlex rack serves as highly scalable and high performance hyperconverged infrastructure building block for modern and cloud native data center workloads. PowerFlex rack architecture is based on Dell PowerEdge servers, Cisco Nexus switches, Dell PowerSwitch switches, and PowerFlex software-defined storage. PowerFlex Manager provides the management and orchestration functionality for PowerFlex rack.

For additional PowerFlex rack documentation, go to PowerFlex rack technical documentation.

Overview

PowerFlex rack is an engineered system designed to meet modern data center needs. You can deploy two layer (separate compute-only and storage-only nodes), fully converged, storage-only, PowerFlex file nodes or hybrid combinations. PowerFlex allows for block and file storage within the same system.

PowerFlex rack is a modular software-defined compute and storage platform that enables linear performance with scale and flexible deployment options for next-generation cloud applications and mixed workloads. The scale-out architecture of the PowerFlex rack enables you to add PowerFlex nodes with various CPU, memory, and drive configuration options to meet the business need. PowerFlex rack is designed for deployments involving large numbers of virtualized and bare metal workloads. PowerFlex rack is built-in N+1 redundancy at component level to deliver high availability.

PowerFlex rack has many advantages:

- Engineered system with automated end-to-end life cycle management using PowerFlex Manager
- Integrated architecture with choice of the following network topologies to meet scale and performance business needs:
  - Access and aggregation
  - Leaf-spine
- Vendor choice on network hardware: Cisco Nexus or Dell PowerSwitch switches
- Multiple PowerFlex node types and node configurations options to meet compute and storage needs
  - PowerFlex hyperconverged nodes
  - PowerFlex storage-only nodes
  - PowerFlex compute-only nodes
  - PowerFlex file nodes
- Flexible compute and storage resources deployment options such as
  - **Hyperconverged** - compute and storage in same chassis allowing proportional scale
  - **Two layer** - compute and storage deployed in separate chassis allowing independent scale of compute and storage resources
  - **Storage only** - only storage resources are part of PowerFlex rack, compute resides outside the system boundaries
  - **Hybrid** - combination of two or more of the above deployment options
- Highly available management and orchestration (M&O) control plane that runs on a dedicated three or more physical nodes cluster
- Supports VMware ESXi and bare metal options
- Software and hardware-based data at rest encryption (D@RE) options
  - Dell CloudLink
  - Optional SEDs
- Supports 25 GbE or 100 GbE port bandwidth for backend connectivity
- Dual network environment using your existing software-defined network (SDN), such as Cisco ACI (optional) or VMware NSX
- Supports both block and file storage
- Support for management aggregation switches (optional)

- Supports native asynchronous replication between sites
- Built-in component level redundancy to ensure data availability
- Self-healing architecture with integrated call home feature
- Storage only option allows external compute resources to access data in the PowerFlex rack
- PowerFlex nodes support:
  - SSD
  - NVMe technologies
  - Software Defined Persistent Memory (SPDM) for PowerFlex R760 and R660 nodes
  - NVDIMM for PowerFlex R750 and R650 nodes
- Purpose-built cabinet with cutting edge security features such as multi-level access controls, alerting, monitoring and reporting, and environmental features to meet modern data center needs
- Supports multi-VLAN or multi-subnet for the same network type, other than data networks, vSAN, and NSX overlay
- Supports non-root user, SSH key pairs and LDAP users for PowerFlex administration functions for security
- PowerFlex file supports the following:
  - NAS server and filesystem clone
  - File-level retention (FLR)
  - Multi-tenancy

Common PowerFlex terms and associated acronyms

This section identifies common PowerFlex terms and associated acronyms.

Table 1. Common PowerFlex terms and associated acronyms

Term	Acronym
management virtual machine	MVM
management data store	MDS
PowerFlex management controller	PFMC
PowerFlex management platform	PFMP
storage data client	SDC
storage data server	SDS
storage virtual machine	SVM
storage data replicator	SDR
storage data target	SDT

See the PowerFlex glossary for more information about PowerFlex terms and acronyms.

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Revision history

Table 2. Revisions

Date	Document revision	Description of changes
May 2024	3.0	Added information for: ● Software-defined persistent memory ● NAS server and filesystem clone ● File-level retention ● Multi-tenancy Updated support for: ● Technology integration
January 2024	2.2	Updated information for protection domain
November 2023	2.1	Updated the cabinet and intelligent PDUs physical build information
September 2023	2.0	Added information for: ● Multi-VLAN and multi-subnet configurations ● Policy manager for secure connect gateway ● Global NameSpace ● Common Event Publishing Agent (CEPA) Updated information for: ● Cisco Nexus switches
May 2023	1.2	Updated the aggregation switch options
January 2023	1.1	Editorial updates
August 2022	1.0	Initial release

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Architecture considerations

PowerFlex rack is a modular hyperconverged platform that enables extreme scalability and flexibility for next-generation cloud applications and mixed workloads.

System components

PowerFlex rack contains compute, network, software-defined storage, virtualization, management and orchestration (M&O) control plane and a purpose-built intelligent cabinet.

The following tables lists the software and hardware components of a PowerFlex rack:

Table 3. Software components

Software	Function	Description
PowerFlex Manager	Management and orchestration	PowerFlex Manager is the management layer of the PowerFlex system. It provides the user interface for both the block storage (PowerFlex software) and file storage services as well as lifecycle management of the hardware components in the PowerFlex rack.
PowerFlex	Software defined storage	PowerFlex software, provides block services to the PowerFlex system and is the software-defined storage layer that forms the core of the offer.
PowerFlex file	Software defined file storage	Network attached storage enables data access through files instead of block devices - also known as file shares. This is the software that provides file services to the PowerFlex system.
VMware vSphere	Virtualization	• VMware ESXi: This is the default supported hypervisor for PowerFlex in both PowerFlex compute-only and PowerFlex hyperconverged nodes. • VMware vCenter Server Appliance (vCSA): The VMware vCSA provides management services to the VMware compute environment including both compute-only and hyperconverged nodes in the PowerFlex system. For PowerFlex rack deployments it also manages the virtual machines of the PowerFlex management controller.
Secure connect gateway	Call home	Secure connect gateway is an enterprise monitoring technology. It monitors your devices and proactively detects hardware issues that may occur. It automates support request creation for issues that are detected on the monitored devices. **NOTE:** Secure connect gateway automatically collects the telemetry that is required to troubleshoot the issue that is detected. The collected telemetry helps technical support to provide a proactive and personalized support experience. Secure connect gateway can be set up with policy manager.
Policy manager	Device access management	Policy manager is a device access management technology delivered as a virtual appliance.
CloudLink (optional)	Software encryption and key management	CloudLink is an optional component that provides key management for self-encrypting drives, and software data-at-rest encryption for non-self-encrypting units.

Table 4. Hardware components

Resource	Vendor	Components
Compute	Dell	PowerFlex nodes: • PowerEdge R660/R760 servers, PowerEdge R650/R750 servers or PowerEdge R640/R740xd/R840 servers for PowerFlex hyperconverged nodes

Table 4. Hardware components (continued)

Resource	Vendor	Components
		• PowerEdge R660/R760/R6625/R7625 servers, PowerEdge R650/R750/R6525/ R7525 servers or PowerEdge R640/R740xd/R840 servers for PowerFlex compute-only nodes • PowerEdge servers R660 or PowerEdge servers R650 for PowerFlex file nodes 4 x 25 Gbe or 4 x 100 Gbe NIC options
Storage	Dell	PowerFlex nodes • PowerEdge R660/R760/R650/R750 servers and/or PowerEdge R640/R740xd servers with PowerFlex software-defined storage
Network	Cisco	Management switch option: • Cisco Nexus 92348GC-X Management aggregation switch option: • Cisco Nexus 93180YC-FX3 Aggregation switch option: • Cisco Nexus 9336C-FX2 Access switch options: • Cisco Nexus 93240YC-FX2 • Cisco Nexus 93180YC-FX3 Spine switch options: • Cisco Nexus 9336C-FX2 • Cisco Nexus 9364C-GX Leaf switch options: • Cisco Nexus 93240YC-FX2 • Cisco Nexus 9336C-FX2 • Cisco Nexus 9364C-GX Border-leaf switch option: • Cisco Nexus 9336C-FX2 Customer access switch (for optional ACI connectivity using dual network) • Cisco Nexus 93240YC-FX2
	Dell	Management switch option: • Dell PowerSwitch S4148T-ON Aggregation switch option: • Dell PowerSwitch S5232F-ON Access switch option: • Dell PowerSwitch S5248F-ON
Management control plane	Dell	PowerFlex management controller: • PowerEdge R660 or PowerEdge R650 servers custom configuration
PowerFlex cabinet	Panduit	PowerFlex rack cabinet: • A 42 RU or 48 RU purpose-built cabinet • Intelligent PDUs with security access control, alerting, monitoring, reporting and environmental features • Cabinet designed for thermal passive air flow

Key architecture considerations

One of the key value propositions of PowerFlex rack is integrated scalable network architecture. In addition to vendor (Cisco or Dell), PowerFlex rack architecture offers the following network topologies:

- Access and aggregation
- Leaf-spine

PowerFlex rack also offers the ability to support both hardware enabled software-defined networking (Cisco ACI) and native software-defined networking (VMware NSX).

PowerFlex rack offers the following four node configuration types to meet performance, scale, and storage and compute capacity business requirements.

- PowerFlex hyperconverged nodes
- PowerFlex compute-only nodes
- PowerFlex storage-only nodes
- PowerFlex file nodes

You can deploy these nodes using one or more of the following resource deployment options.

- Hyperconverged deployment
- Storage-only deployment
- Two-layer deployment with disaggregated compute and storage-only nodes
- Hybrid deployment as a combination of above
- PowerFlex file deployment

PowerFlex Manager allows you to specify a non-root user when configuring a template for a compute-only, storage-only, or hyperconverged deployment.

Network architecture

PowerFlex rack is available as two different network architectures to meet performance and scaling requirements.

Access and aggregation architecture

The following figure is a high-level, system layout of the PowerFlex rack using an access and aggregation architecture. This figure is not specific to a particular system, but is a generic representation. The aggregation and management aggregation switches can be spread across multiple cabinets for additional resiliency.

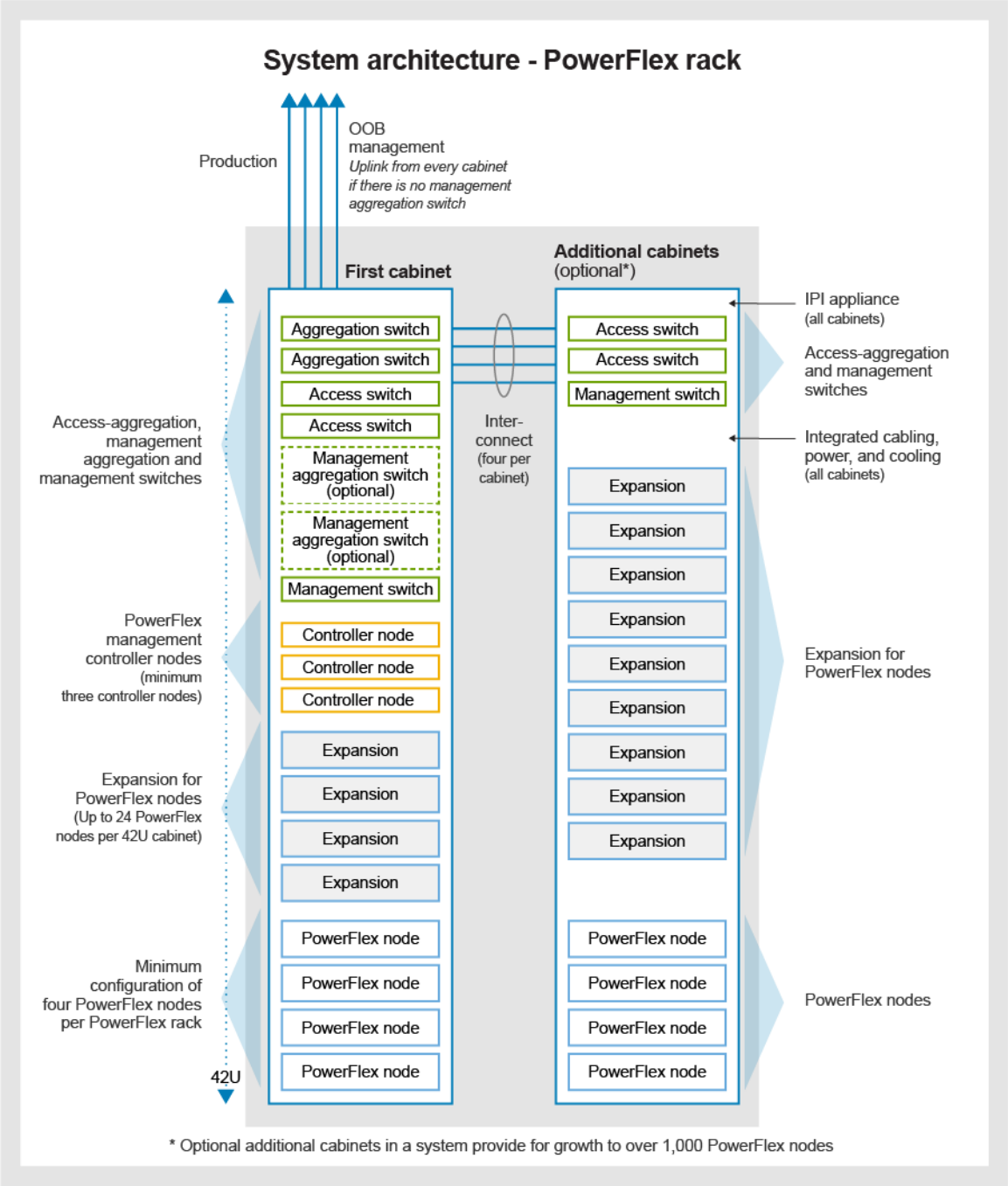

Figure 1. System architecture using an access-aggregation architecture

The following figure shows the logical layout of the access and aggregation architecture:

NOTE: There is an additional 10/25 Gb link from the PowerFlex controller nodes to the out-of-band management switch.

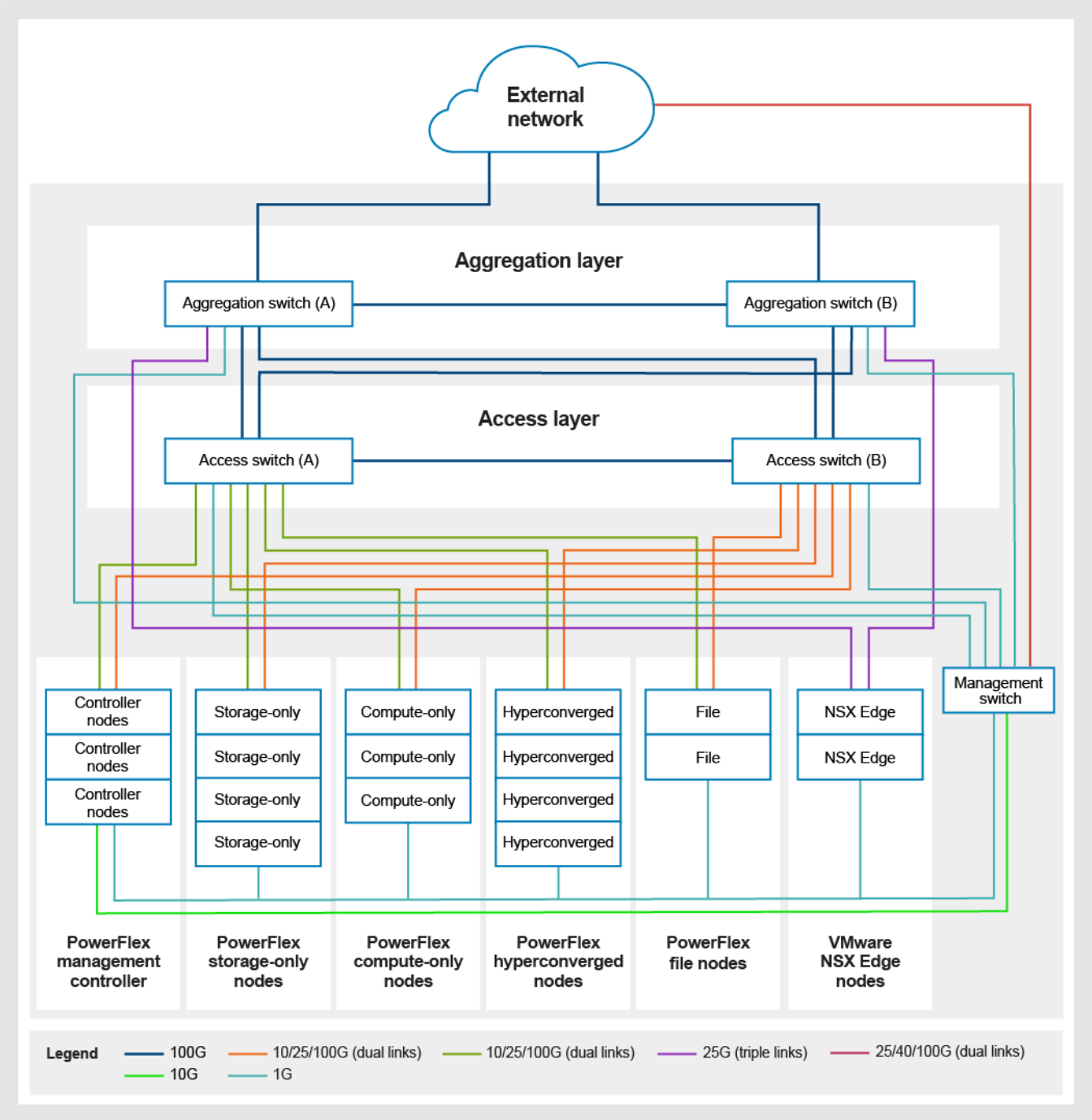

Figure 2. Logical layout of the access and aggregation architecture

The following figure shows the logical layout of the access and aggregation with management-aggregation switch architecture:

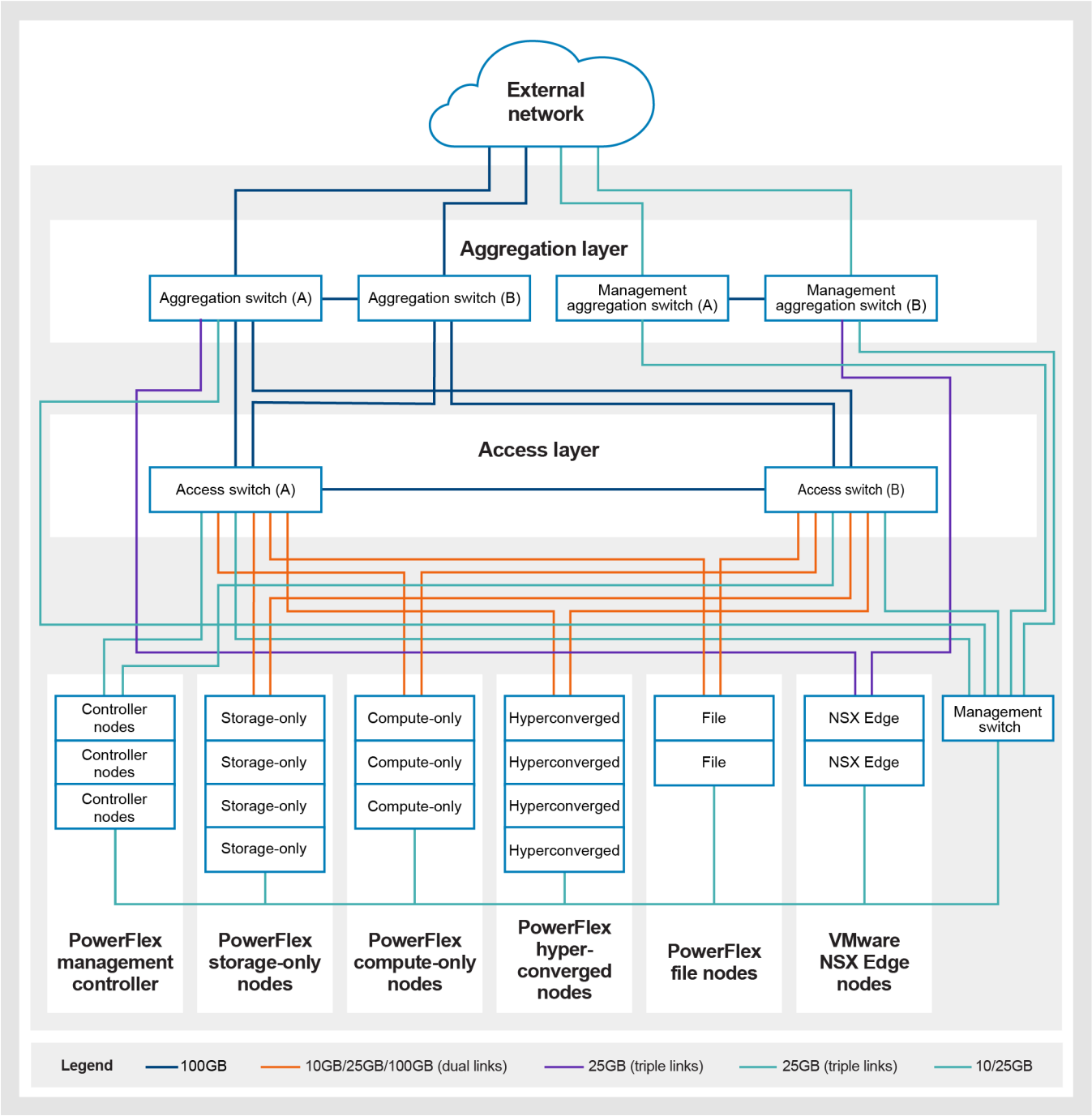

Figure 3. Logical layout of the access and aggregation with management-aggregation switch architecture

Leaf-spine architecture

Leaf-spine architecture is 100 GbE connectivity from every spine to every leaf. Network switches provide two options to support leaf-to-node connectivity.

The following figure is a high-level, system layout of the physical PowerFlex rack, designed using a leaf-spine architecture:

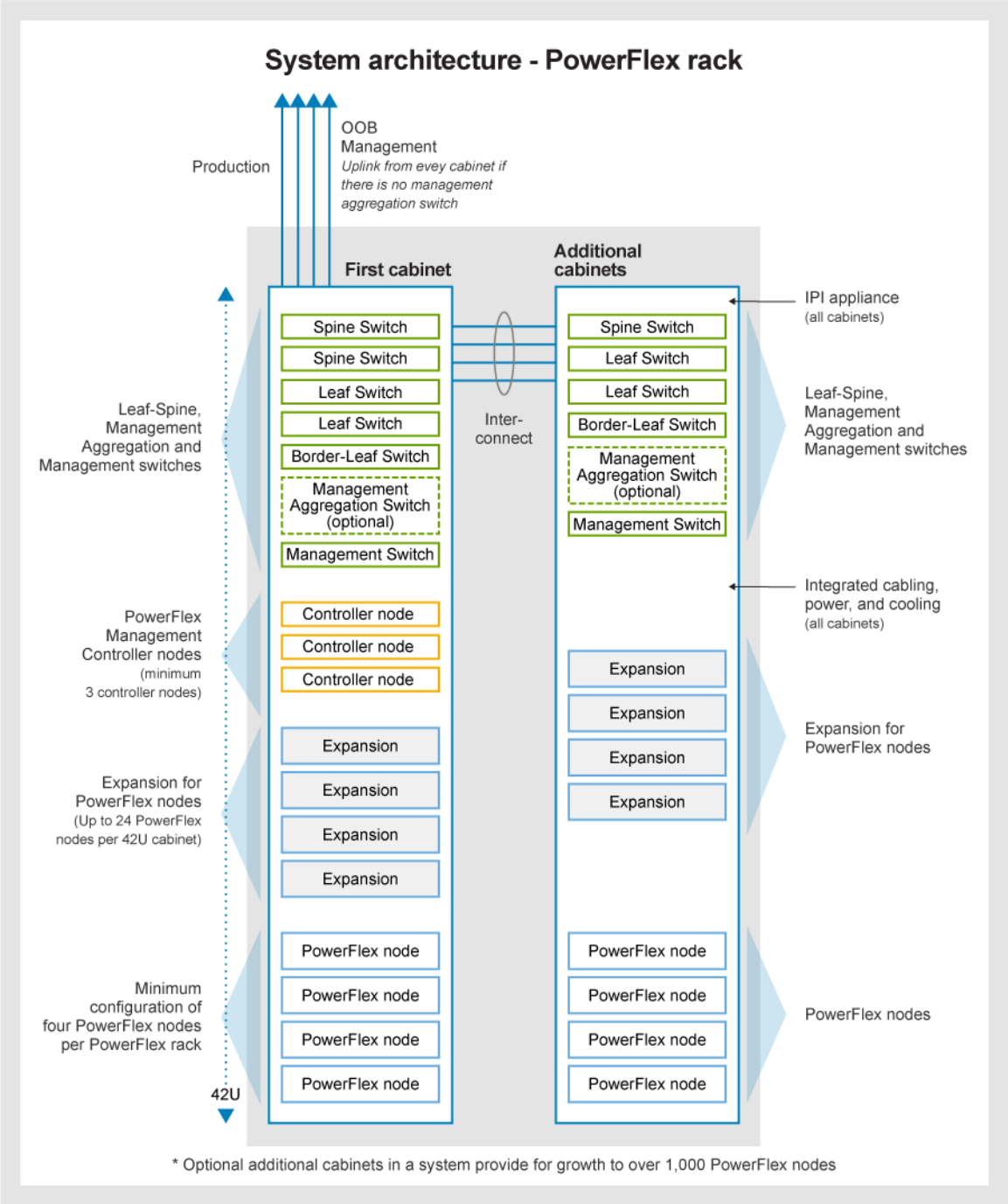

Figure 4. System architecture using an access-aggregation architecture

The following diagram shows the logical layout of the leaf-spine architecture:

NOTE: There is an additional 10/25 Gb link from the PowerFlex controller nodes to the out-of-band management switch.

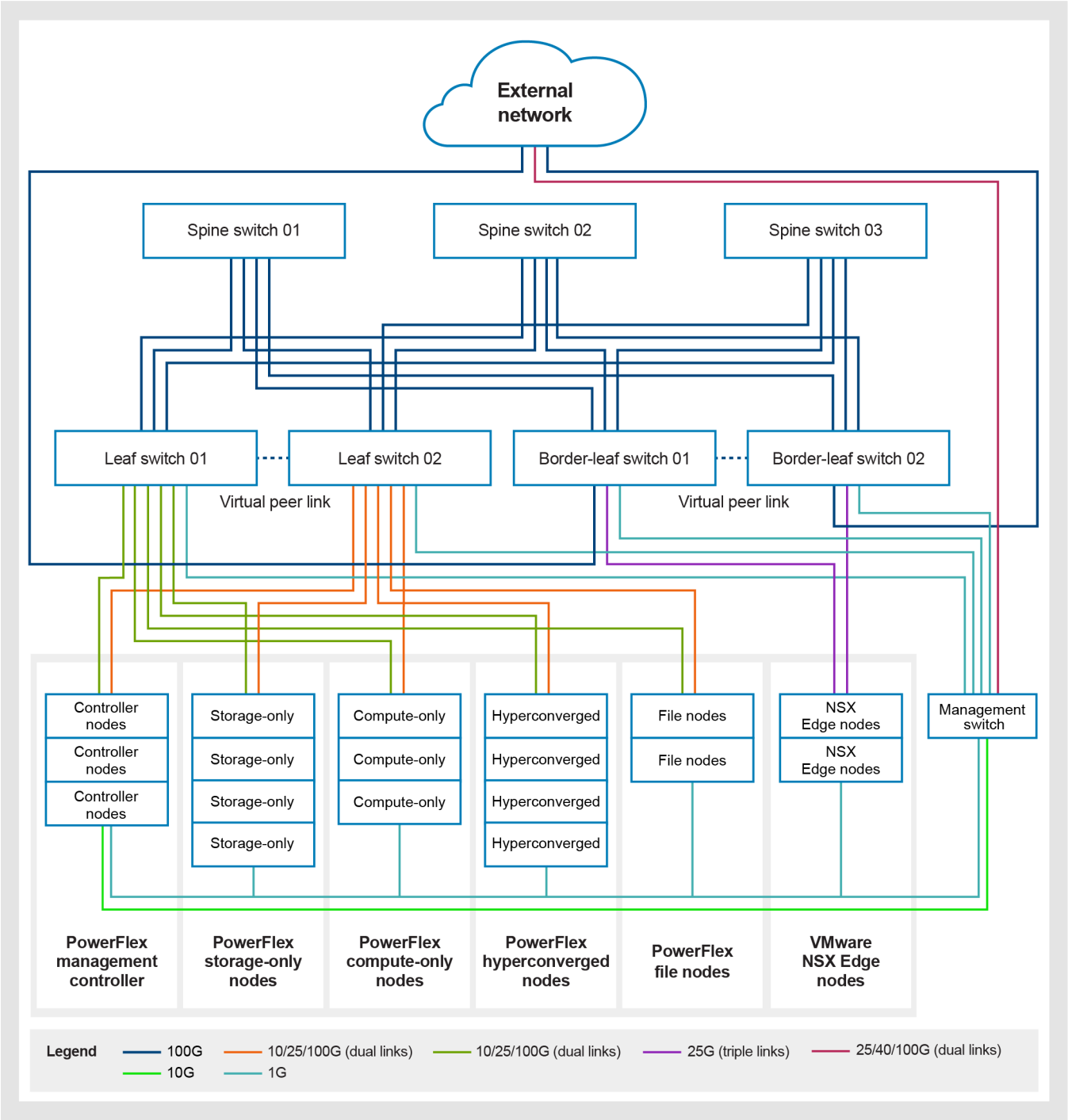

Figure 5. Logical layout of the leaf-spine architecture

The following diagram shows the logical layout of the leaf-spine with management-aggregation switch architecture:

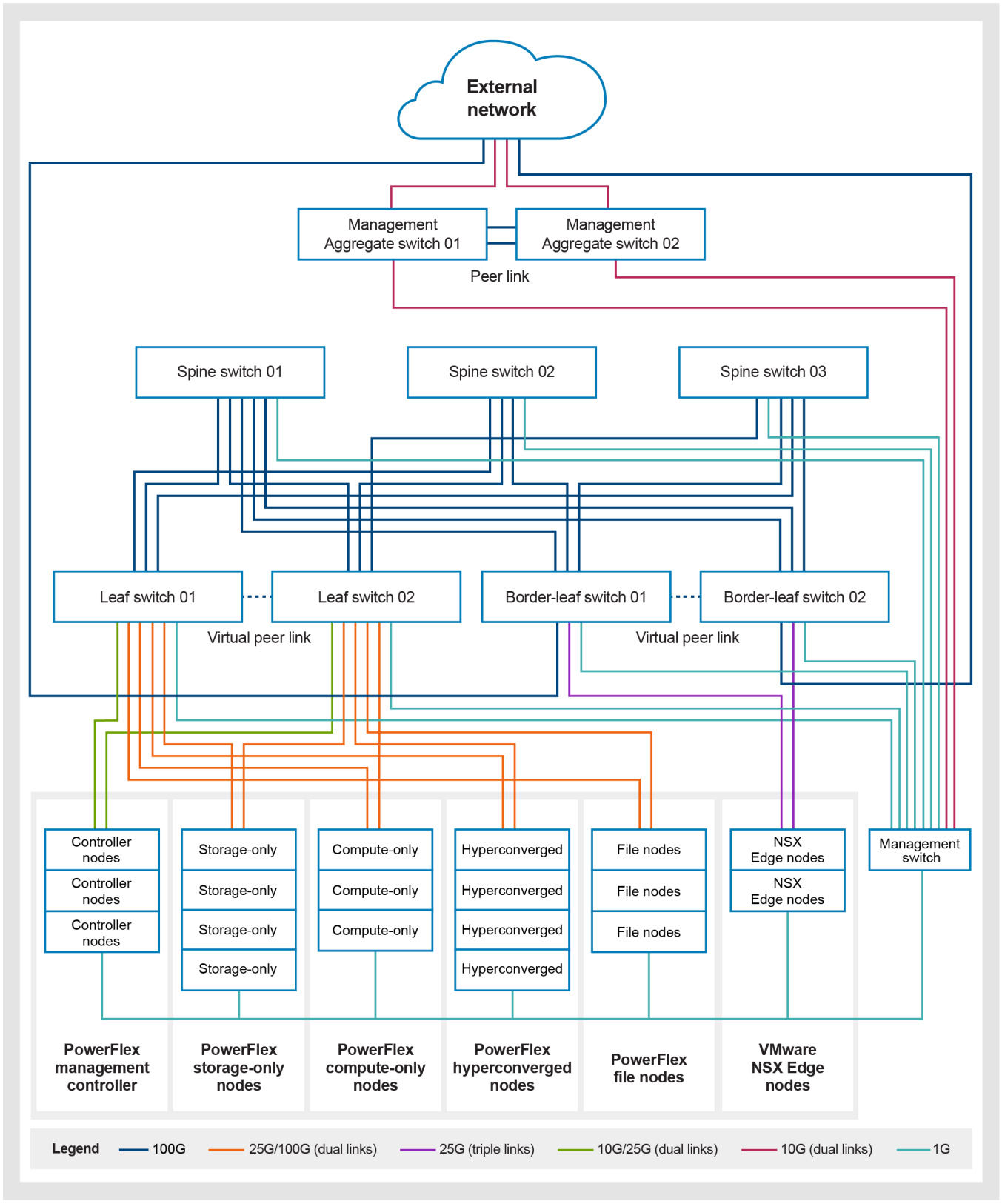

Figure 6. Logical layout of the leaf-spine with management-aggregation switch architecture

VMware NSX ready architecture

The VMware NSX ready deployment is a variation of standard deployment that includes PowerFlex hyperconverged or PowerFlex compute-only nodes. This includes an additional VMware NSX Edge node cluster deployment.

The following table contains VMware NSX ready requirements for each VMware vSphere cluster:

Table 5. VMware NSX ready requirements

VMware vSphere cluster	Requirements for PowerFlex rack
Management cluster	Created as a single VMware vSphere cluster and added within the PowerFlex data center. • The three NSX Manager VMs run in this cluster.
NSX Edge cluster	• Created as a single VMware vSphere cluster and added in the PowerFlex vCenter Server. • HA enabled and DRS disabled at the VMware vSphere cluster level, if running the vSAN storage option. • Deployed across multiple physical racks (split between two PowerFlex racks). • By default, local storage with RAID 1+0 is enabled. However, vSAN is supported if you or VMware services choose this option. • Includes NSX Edge Gateway VMs, deployed at the customer site, that provide logical routing. • At minimum, four of the six NIC interfaces that are used for transport and external edge traffic must be configured as an individual trunk. The other two NIC interfaces that are used for VMware ESXi management or vSAN traffic are configured with link aggregation control protocol (LACP) enabled vPC. **NOTE:** Do not deploy non-NSX Edge workloads in the NSX Edge VMware vSphere cluster.
Compute cluster	• On a compute cluster, the front-end distributed switch must be configured as trunk ports. The switch carries overlay NSX ready transport traffic, and VMware does not recommend using LACP. • Includes the customer production VMs to run on the NSX transport overlay VMkernel.

PowerFlex storage-only deployment

A PowerFlex rack storage-only deployment has a base configuration that is a minimum set of PowerFlex storage-only nodes and fixed network resources.

Within the base configuration, you can customize the following hardware aspects:

Table 6. PowerFlex storage-only deployment requirements

Hardware	Minimum set
Network	• One management switch • One pair of access or leaf switches • One pair of aggregation switches or three spine switches • One pair of management aggregation switches (optional) • One pair of border-leaf switches **NOTE:** Only in a leaf-spine configuration.
Storage	At least four PowerFlex storage-only nodes are required. However, Dell Technologies recommends using at least six nodes to build a PowerFlex storage pool. If storage compression is active, two SDPM components (for PowerFlex R660 or PowerFlex R760) or a minimum of two NVDIMM components (for PowerFlex R650 or PowerFlex R750) per PowerFlex node are required. A recommendation is made according to the system sizing calculation.
Management	Three PowerFlex controller nodes with high availability.

PowerFlex two-layer deployment

A PowerFlex rack two-layer deployment has a base configuration that is similar to a PowerFlex storage-only node deployment, but adds a minimum set of PowerFlex compute-only nodes. The minimum set of PowerFlex storage-only nodes and fixed network resources are also required.

Within the base configuration, you can customize the following hardware aspects:

Table 7. PowerFlex two-layer deployment requirements

Hardware	Minimum set
Compute	At least three PowerFlex compute-only nodes.
Network	• One management switch • One pair of access or leaf switches • One pair of aggregation switches or three spine switches • One pair of management aggregation switches (optional) • One pair of border-leaf switches **NOTE:** Only in a leaf-spine configuration.
Storage	At least four PowerFlex storage-only nodes are required. However, Dell Technologies recommends using at least six nodes to build a PowerFlex storage pool. Software-defined SAN storage (uses local disks to build a PowerFlex storage pool). If storage compression is active, two SDPM components (for PowerFlex R660 or PowerFlex R760) or a minimum of two NVDIMM components (for PowerFlex R650 or PowerFlex R750) per PowerFlex node are required. A recommendation is made according to the system sizing calculation.
Management	Three PowerFlex controller nodes with high availability.

PowerFlex hyperconverged deployment

A PowerFlex rack has a base configuration that is a minimum set of hyperconverged components and fixed network resources.

Within the base configuration, you can customize the following hardware aspects:

Table 8. PowerFlex hyperconverged deployment requirements

Hardware	Minimum set
Compute and storage	A minimum of four PowerFlex hyperconverged nodes are required, however, six is the recommended minimum. PowerFlex hyperconverged nodes provide both storage and compute resources to the system. If storage compression is active, two SDPM components (for PowerFlex R660 or PowerFlex R760) or a minimum of two NVDIMM components (for PowerFlex R650 or PowerFlex R750) per PowerFlex node are required. A recommendation is made according to the system sizing calculation.
Network	• One management switch • One pair of access or leaf switches • One pair of aggregation switches or three spine switches • One pair of management aggregation switches (optional) • One pair of border-leaf switches **NOTE:** Only in a leaf-spine configuration.
Management	Three PowerFlex controller nodes with high availability.

VMware NSX Edge node deployment

The NSX ready deployment consists of the specification provided in the following table:

Table 9. VMware NSX Edge node deployment requirements

Hardware	Minimum set
Compute	VMware NSX transport is configured on PowerFlex compute-only nodes or hyperconverged nodes.
Network	• Supports either a traditional Ethernet architecture (Cisco Nexus or Dell PowerSwitch) or leaf-spine topology (Cisco Nexus). • By default, the NSX Edge physical nodes connect directly to either the aggregation or border leaf switches, depending on the network topology. If there is a limitation because of port capacity or cable distance, the management and transport connections (not Edge/BGP uplinks) are relocated from the aggregation or border leaf switches to the access or leaf switches.
Storage	• NSX Edge nodes can run in either a local RAID1+0 storage (recommended) or a VMware vSAN storage solution. • NSX Managers will run on the general shared datastores provided by PowerFlex within the PowerFlex management cluster. • PowerFlex storage-only nodes are not supported as an NSX transport node.
Management	Four PowerFlex controller nodes with high availability. A fourth controller node is included to host NSX Manager.
NSX Edge	• A minimum of two NSX Edge nodes, if using local RAID storage option. • A minimum of four NSX Edge nodes, if using vSAN storage option. Each NSX Edge node uses three dual-port 25 Gb cards to connect to either the border leaf or aggregation switches. At minimum, four of the six NIC interfaces that are used for transport and external edge traffic must be configured as an individual trunk. The other two NIC interfaces that are used for VMware ESXi management or vSAN traffic are configured with link aggregation control protocol (LACP) enabled vPC. **NOTE:** Do not deploy non-NSX Edge workloads in the NSX Edge VMware vSphere cluster.

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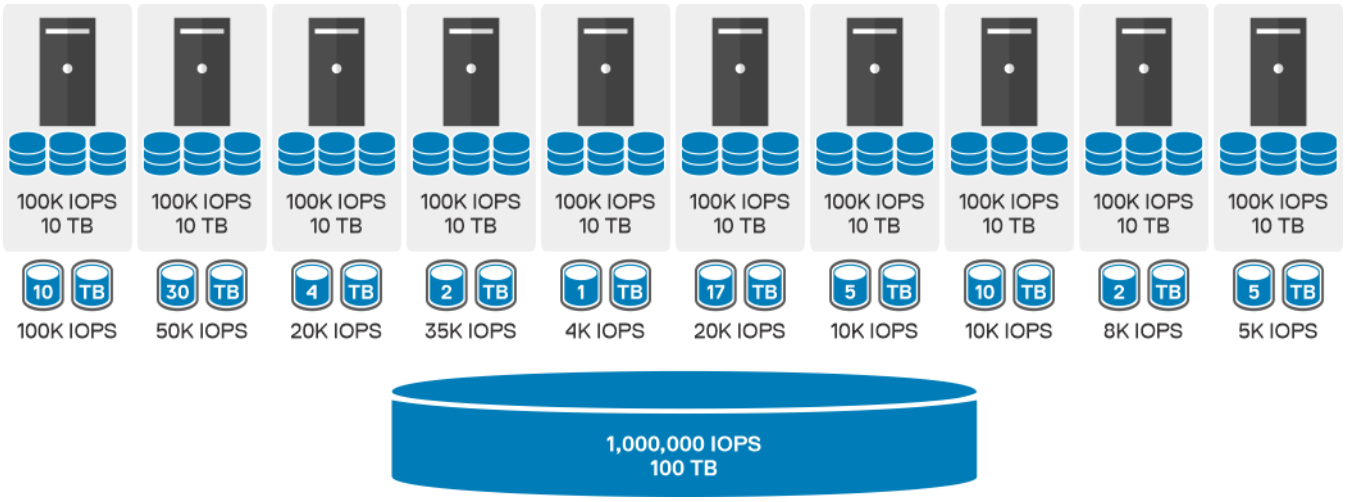
PowerFlex software-defined storage architecture

PowerFlex applies the principles of server virtualization to standard x86 servers with local disks, creating high-performance, sharable pools of block storage. PowerFlex abstracts the local storage contained within each server.

PowerFlex pools all the storage resources together. In the following figure, there is a global pool of 1 million IOPS and 100 terabytes, instead of having 100K IOPS and 10 terabytes available in each server. The applications are not constrained by what is within the local server, these resources are shared across the entire cluster.



PowerFlex automatically maintains balance across all resources, supporting application needs. Storage and/or compute can be added dynamically with no downtime or impact to applications because PowerFlex seamlessly balances the available resources. This enables data center operation in the most efficient and cost-effective way possible, regardless of organization size.

PowerFlex components

Storage data client (SDC)

The storage data client (SDC) is installed on PowerFlex nodes that consume the system storage volumes. The volumes data and copies are spread evenly across the nodes and drives that comprise the pool. The storage data client communicates over multiple pathways to all the nodes. In this multi-point peer-to-peer fashion, it reads and writes data to and from all points simultaneously, eliminating bottlenecks and quickly routing around failed paths. The storage data client:

- Provides front-end volume access to applications and file systems.
- Is installed on servers consuming storage.
- Maintains peer-to-peer connections to every storage data server managing a pool of storage.

Storage data server (SDS)

The storage data server is installed on every PowerFlex node that contributes its storage to the system. It owns the contributing drives and together with the other storage data servers forms a protected mesh from which storage pools are created. Volumes carved out of the pool are presented to the storage data clients for consumption. The storage data server:

- Abstracts local storage, maintains storage pools, and presents volumes to the storage data clients.
- Is installed on servers contributing local storage to the cluster.

Metadata manager (MDM)

The metadata manager software installs on three or five PowerFlex nodes and forms a cluster that supervises the operations of the entire cluster and its parts, while staying outside of the data path itself. The metadata manager hands out instructions to each storage data client and storage data server about its role and how to perform it, giving each component the information it needs. The metadata manager:

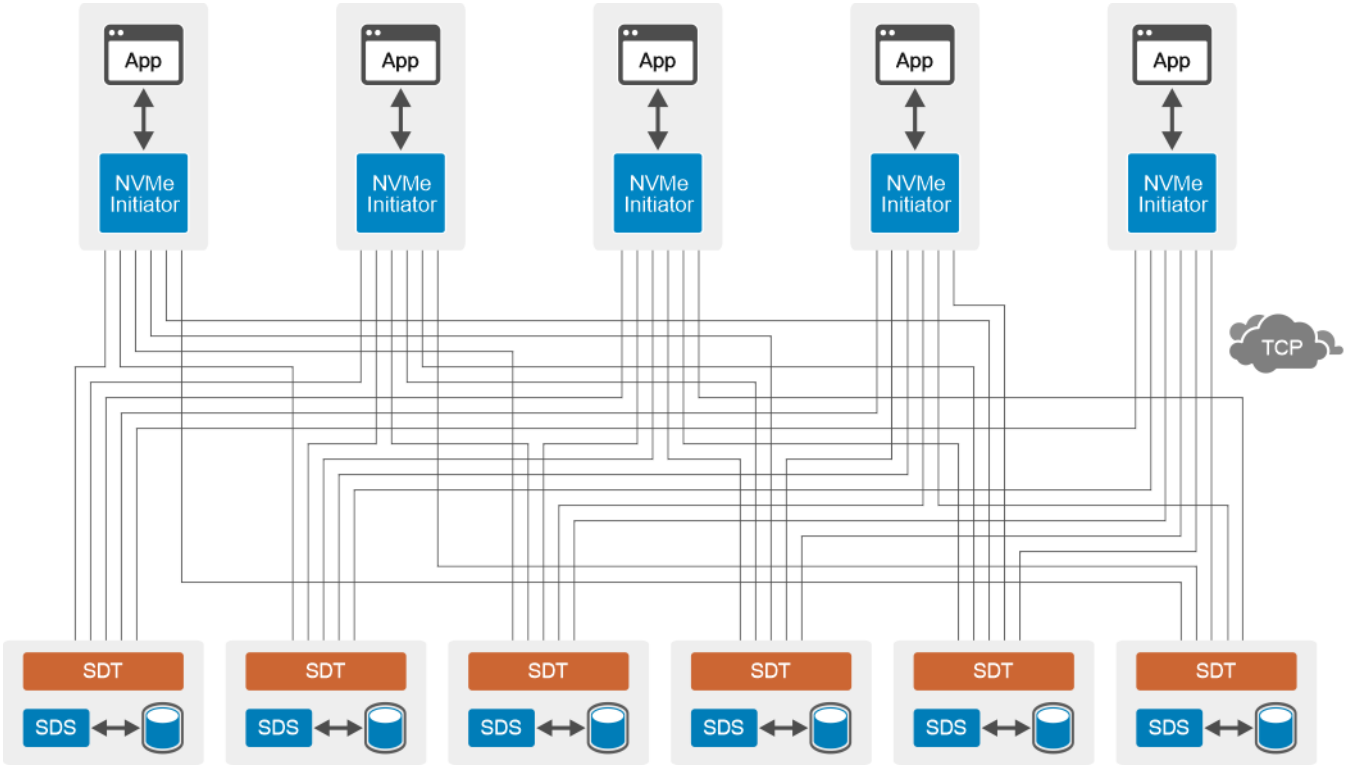
- Oversees storage cluster configurations, monitoring, rebalances, and rebuilds.
- Is a highly available, independent cluster installed on three or five different PowerFlex nodes.
- Sits outside the data path.

Storage data replicator (SDR)

The storage data replicator proxies the I/O of replicated volumes between the storage data client and the storage data servers where data is ultimately stored. It splits writes, sending one copy to the destination storage data servers and another to a replication journal volume. Sitting between the storage data server and storage data client, from the point-of-view of the storage data server, the storage data replicator appears as if it were an storage data client sending writes (from a networking perspective, however, the storage data replicator to storage data server traffic is still backend/storage traffic). Conversely, to the storage data client, the storage data replicator appears as if it were an storage data server to which writes can be sent. The storage data replicator only mediates the flow of traffic for replicated volumes. Non-replicated volume I/Os flow, as usual, between storage data clients and storage data servers directly. As always, the metadata manager instructs each of the storage data clients where to read and write their data. The volume address space mapping, presented to the storage data client by the metadata manager, determines where the volumes data is sent. But the storage data client is not aware of the write-destination as an storage data server or an storage data replicator. The storage data client is not aware of replication.

Storage data target (SDT)

The storage data target (SDT) is installed with the storage data server to connect compute/application clients to storage using NVMe over TCP. NVMe over TCP front-end capability allows you to use agentless solution (no storage data client), providing more flexible options for operating systems where storage data client is not supported and reducing the operational complexity of deploying and maintaining the host agent.



Storage schemas

Protection domains

A protection domain (PD) is a group of nodes or storage data servers that provide data isolation, security, and performance benefits. A node participates in only one protection domain at a time. Only nodes in the same protection domain can affect each other, nodes outside the protection domain are isolated. Secure multi-tenancy can be created with protection domains since data does not mingle across protection domains. You can create different protection domains for different node types with unequal performance profiles. All the hosts in the domain must have the same type and configuration. A PowerFlex hyperconverged node should not be in the same protection domain as a PowerFlex storage-only node. The node configuration must match, which includes the drives, CPU, and memory. Any difference in the node configuration leads to an unknown performance impact.

Storage pools

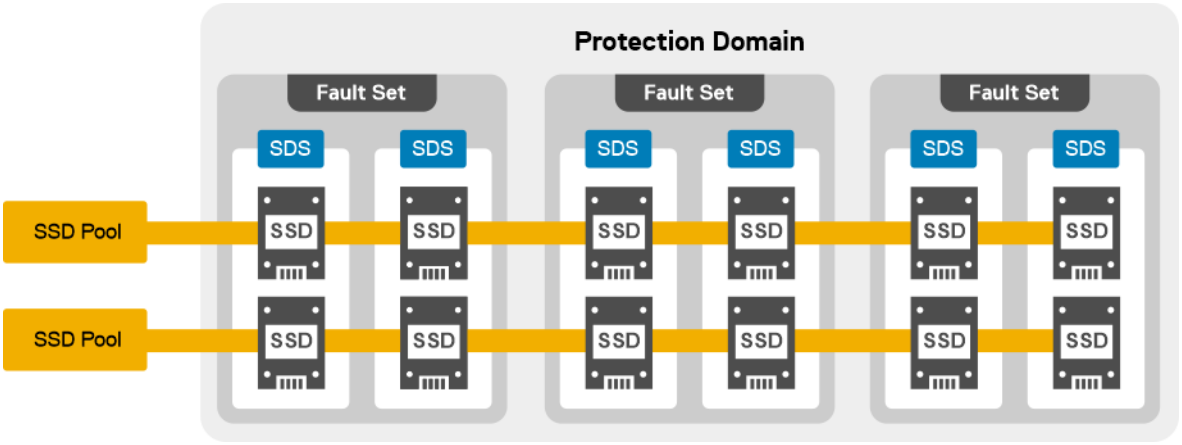
Storage pools are a subset of physical storage devices in a protection domain. Each storage device belongs to one (and only one) storage pool. The best practice is to have the same type of storage devices (HDD versus SSD or SSD versus NVMe) within a storage pool to ensure that the volumes are distributed over the same type of storage within the protection domain.

PowerFlex supports two types of storage pools. You can choose between both layouts. A system can support both fine granularity (FG) and medium granularity (MG) pools on the same storage data server nodes. Volumes can be non-disruptively migrated between the two layouts. Within an fine granularity pool, you can enable or disable compression on a per-volume basis:

- **Medium granularity:** Volumes are divided into 1MB allocation units, distributed, and replicated across all disks contributing to a pool. MG storage pools support either thick or thin-provisioned volumes, and no attempt is made to reduce the size of user-data written to disk (except with all-zero data). MG storage pools have higher storage access performance than fine granularity storage pools but use more disk space.
- **Fine granularity:** A space efficient layout, with an allocation unit of just 4 KB and a physical data placement scheme based on log structure array (LSA) architecture. Fine granularity layout requires both flash media (SSD or NVMe) as well as SDPM or NVDIMM to create an fine granularity storage pool. fine granularity layout is thin-provisioned and zero-padded by nature, and enables PowerFlex to support in-line compression, more efficient snapshots, and persistent checksums. Fine granularity storage pools use less disk space than medium granularity storage pools but have slightly lower storage access performance.

Fault sets

A fault set is a logical entity that contains a group of storage data servers within a protection domain that have a higher chance of going down together; for example, if they are all powered in the same rack. By grouping them into a fault set, PowerFlex mirrors data for a fault set on storage data servers that are outside the fault set. Thus, availability is assured even if all the servers within one fault set fail simultaneously.



PowerFlex features

PowerFlex is an enterprise-class, software-defined solution that is deployed, managed, and supported as a single system.

Replication

The following figure depicts where the SDR fits into the overall PowerFlex replication architecture:

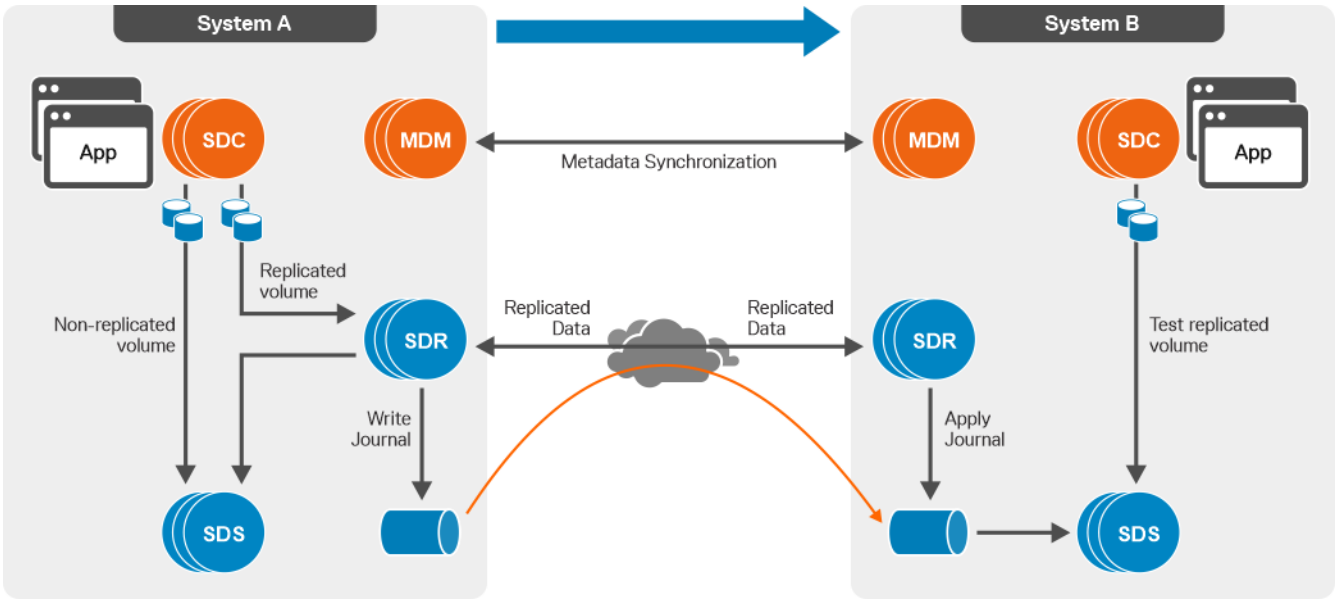


Figure 7. PowerFlex replication architecture

PowerFlex enables native asynchronous replication for PowerFlex storage-only and PowerFlex hyperconverged configurations.

Replication can be used to quickly and easily recover from a physical or logical disaster, to migrate data, to test data at a remote site, or to offload backup. The PowerFlex implementation is designed to allow a sub-minute recovery point objective (RPO) reducing the data-loss to minimal in case of disaster recovery. As with all other PowerFlex data services, the replication is elastic, can scale online by adding or removing nodes, flexible, and easy to manage. It enables instant test and failover operations.

The storage data replicator proxies the I/O of replicated volumes between the SDC and the SDSs where data is ultimately stored. Write I/Os are split, sending one copy on to the destination SDSs and another to a replication journal volume. Sitting between the SDS and SDC, from the point-of-view of the SDS, the SDR appears as if it were an SDC sending writes. (From a networking perspective, however, the SDR to SDS traffic is still backend/storage traffic.) Conversely, to the SDC, the SDR appears as if it were an SDS to which writes can be sent. The SDR only mediates the flow of traffic for replicated volumes. (In fact, only actively replicating volumes; the nuance will be covered below). Non-replicated volume I/Os flow, as usual, between SDCs and SDSs directly. As always, the MDM instructs each of the SDCs where to read and write their data. The volume address space mapping, presented to the SDC by the MDM, determines where the volume's data is sent. But the SDC is ignorant of the write-destination as an SDS or an SDR. The SDC is not aware of replication.

Compression

Fine granularity (FG) layout requires both flash media (SSD or NVMe) as well as SDPM or NVDIMM to create an fine granularity pool. Fine granularity layout is thin-provisioned and zero-padded by nature, and enables PowerFlex to support in-line compression, more efficient snapshots, and persistent checksums. Fine granularity pools support only thin-provisioned, zero-padded volumes, and whenever possible the actual size of user-data stored on disk will be reduced. Users should expect an average compression ratio of at least 2:1. Because of the 4K allocation, fine granularity pools drastically reduce snapshot overhead, because new writes and updates to the volumes data do not each require a 1 MB read/copy action. All data written to an fine granularity pool receives a checksum and is tested for compressibility. The checksum for every write is stored with the metadata and adds an additional layer of data integrity to the system.

PowerFlex offers a distinctive, competitive advantage with the ability to enable compression per-volume versus globally, and the ability to choose the best layout for each individual workload. The medium granularity layout is still the best choice for workloads

with high performance requirements. Fine granularity pools offer space-saving services and additional data integrity. Within an fine granularity pool, enabling compression or making heavy use of snapshots has almost zero impact on the performance of the volumes.

Snapshots

Snapshots are a block image in the form of a storage volume or LUN (logical unit number) used to instantaneously capture the state of a volume at a specific point in time. Snapshots can be initiated manually or by new, automated snapshot policies. Snapshots in fine granularity storage pools are more space efficient and have better performance in comparison to MG snapshots. PowerFlex supports snapshot policies based on a time retention mechanism. Users can define up to 60 policy-managed snapshots per root volume A snapshot policy defines a cadence and the number of snapshots to keep at each level.

Volume migration

Migration is non-disruptive to ongoing I/O and is supported across storage pools within the same protection domain or across protection domains. Migrating volumes from one storage pool migrates the volume and all its snapshots together (known as vTree granularity). There are several use cases where volume migration would be useful:

- Migrating volumes between different storage performance tiers
- Migrating volumes to a different storage pool or protection domain driven by multi-tenancy needs
- Extract volumes from a deprecating storage pool or protection domain to shrink a system
- Change a volume personality between thick or thin or fine granularity or medium granularity

5

System hardware

System hardware consists of multiple sections on how PowerFlex nodes are used.

There are four types of PowerFlex nodes: storage providing nodes, storage consuming nodes, management nodes and VMware NSX Edge nodes. PowerFlex hyperconverged nodes provide storage and consume storage. The table below shows the combinations of provision and consumption allowed by PowerFlex rack.

Table 10. Combinations of provision and consumption allowed by PowerFlex rack

PowerFlex storage provided by ...				
PowerFlex storage consumed by...	-	**Hyperconverged**	**Hyperconverged and storage only**	**Storage-only**
	Compute-only	N/A	Hybrid	Two-layer
	Hyperconverged and compute-only	Hybrid	Hybrid	Hybrid
	Hyperconverged	Hyperconverged	Hybrid	N/A
	External	N/A	N/A	Storage only

Storage-providing nodes

PowerFlex hyperconverged nodes

PowerFlex hyperconverged nodes are based on Dell PowerEdge R660, R760, R650, R750, R640, R740xd, and R840 servers. PowerFlex is deployed on these nodes in a true hyperconverged form where PowerFlex SDC and SDS software components are installed on the same PowerFlex node. PowerFlex hyperconverged nodes nodes provide and consume storage.

PowerFlex storage-only nodes

PowerFlex storage-only nodes are based on Dell PowerEdge R660, R760, R650, R750, R640, R740xd, and R840 servers. PowerFlex storage-only nodes are designed to provide storage capacity but no compute power to the compute cluster. Only the SDS component of the PowerFlex runs on PowerFlex storage-only nodes. PowerFlex storage-only nodes run an embedded operating system and do not require any VMware ESXi license. PowerFlex storage-only nodes have the ability to add additional storage capacity to a PowerFlex cluster without additional compute power.

Storage-consuming nodes

PowerFlex hyperconverged nodes

PowerFlex hyperconverged nodes are based on PowerEdge R660, R760, R650, R750, R640, R740xd, and R840 servers. PowerFlex is deployed on these nodes in a true hyperconverged form where the PowerFlex data client and storage data serve software components are installed on the same PowerFlex node. PowerFlex hyperconverged nodes provide and consume storage.

PowerFlex compute-only nodes

PowerFlex compute-only nodes are based on PowerEdge R660, R760, R6625, R7625, R650, R750, R6525, R7525, R640, R740xd, and R840 servers. The PowerFlex compute-only node enables you to deploy PowerFlex in a two-layer architecture that delivers ultimate flexibility when it comes to independently scaling compute and storage resources. The PowerFlex SDC software component is installed on PowerFlex compute-only nodes.

PowerFlex file nodes

PowerFlex file nodes are based on PowerEdge R660 and PowerEdge R650 servers with two third generation Intel Xeon scalable processors with up to 24 cores per processor. PowerFlex file nodes are deployed in a cluster of 2 to 16 nodes. The PowerFlex storage data client software component is installed on PowerFlex file nodes.

Management controller

PowerFlex controller nodes

PowerFlex controller nodes are based on the PowerEdge R650 or PowerEdge R660 server. PowerFlex controller nodes use PowerFlex to provide a reliable, and highly available storage cluster for the management plane. PowerFlex rack management clusters have a minimum of three nodes.

NOTE: If VMware NSX ready is deployed then the minimum requirement number of PowerFlex controller nodes is four.

VMware NSX ready nodes

VMware NSX Edge nodes host the VMware NSX Edge gateway instances (VMs), and two or more VMware NSX Edge nodes provided with NSX ready configuration within the PowerFlex rack.

PowerFlex node networking

A PowerFlex rack is based on either access-aggregation or leaf-spine topology. The choice of either access/aggregation or leaf-spine network design options depend on the customer preference. The leaf-spine design option is recommended for high-performance, extremely large scale-out, or greater east-west bandwidth.

General network connectivity descriptions

A pair of access switches is installed in every cabinet to handle all inter-cabinet network traffic between the nodes within the cabinet. Each pair of switches can support up to 24 nodes and/or controllers.

A standard deployment is one pair of access or leaf switches per cabinet. There are circumstances (power, cooling or space constraints) where PowerFlex nodes can reside in an adjacent cabinet. A management switch is installed in the first cabinet to support the out-of-band management (OOB) requirements of the system. Management switches are added on a as needed basis to support network connectivity from the following equipment:

- One for each PowerFlex controller to support management traffic
- One for each PowerFlex controller iDRAC connection
- One for each PowerFlex node iDRAC connections
- One for each IPI cabinet (up to four PDUs)
  - Cabinet with six PDUs requires one additional port
- One for each switch for the OOB connection
- One for service port

6

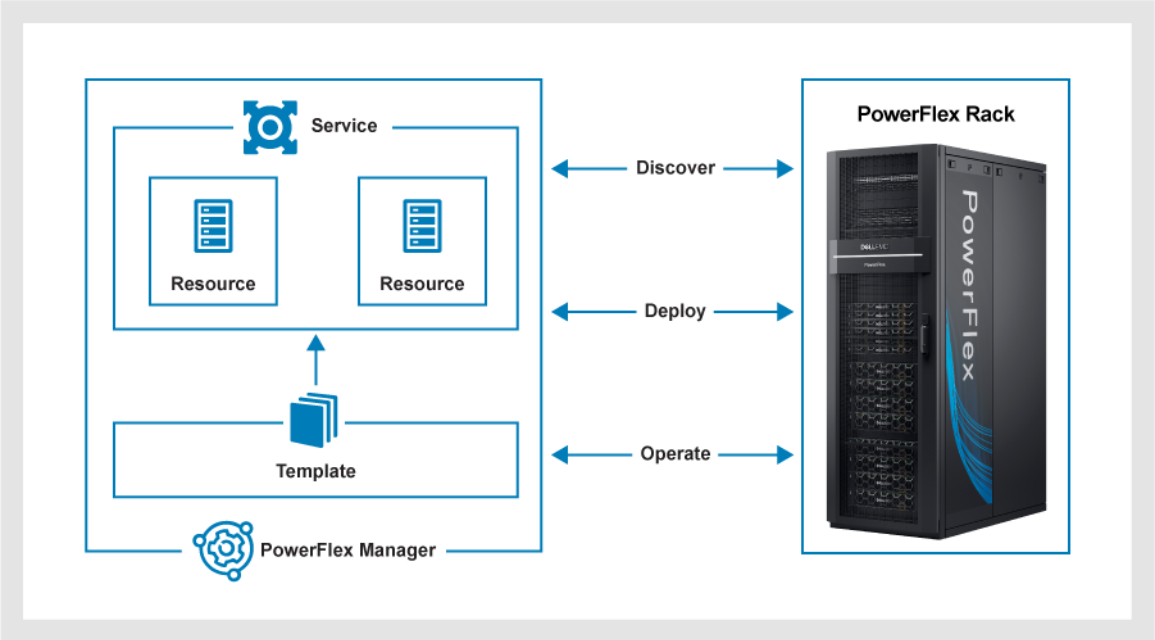
Management control plane

The PowerFlex rack management control plane consists of:

- VMware ESXi to deliver high availability for VMs
- PowerFlex management controller - PowerEdge server with custom configuration
- One of the following:
  - PowerFlex storage data server for cluster storage high availability
  - Single PowerFlex management controller with RAID for data protection
  - Customer provided management controller or controller nodes

The management network connection consists of the following:

- PowerFlex management platform - is the software management and orchestration stack for PowerFlex. It is implemented on the PowerFlex management controller. It includes the container environment running on physical or virtual Linux instances, and containers that provide services.
- PowerFlex Manager - provides IT operations management for PowerFlex rack. It increases efficiency by reducing time-consuming manual tasks that are required to manage system operations. Use PowerFlex Manager to deploy and manage new and existing PowerFlex rack environments.
- PowerFlex Manager discovers, deploys, and operates the PowerFlex rack by using resources, templates, and resource groups.



For more information on key PowerFlex Manager terminology, see the PowerFlex glossary.

PowerFlex Manager offers the following features:

- Resource discovery, inventory, and resources management
- Simplified and efficient day-to-day operations
- Management of block and file storage objects
- Creating template-based configurations for consistent and secure deployment of large number of compute, storage and network resources
- Built-in role-based authorization and identity management
- Comprehensive health alerting, monitoring, reporting and dashboards
- End to end automated life-cycle management

- Life-cycle compliance management and reporting

For an in-depth overview of PowerFlex Manager, see the *Dell PowerFlex Technical Overview*.

- VMware vCenter - is a centralized data center management platform that enables organizations to create and manage virtual machines resided in their on-premise environments. It includes resource provisioning and allocation, monitoring the VMs performance and workflow automation.
- Secure connect gateway (SCG) - is an enterprise monitoring technology that is delivered as an appliance and a stand-alone application. It monitors your devices and proactively detects hardware issues that may occur.
- Policy manager - policy manager is a device access management technology that is delivered as a virtual appliance.

7

PowerFlex file services

PowerFlex has optional native file capabilities that are highly scalable, efficient, performance focused and flexible.

PowerFlex file nodes enable accessing data over file protocols such as server message block (SMB), network file system (NFS) and secure file transfer protocol (SFTP). PowerFlex file nodes supports two primary business cases:

- Traditional NAS: Home directories and file sharing
- Transactional NAS: Database and VMware workloads

PowerFlex file architecture

PowerFlex file is deployed on PowerFlex file nodes to provide file services to applications.

PowerFlex file nodes provide compute capabilities (CPU and memory) and consume storage from PowerFlex block (SDS) providing a highly scalable performance for transactional and traditional workloads. PowerFlex file can be scaled independently of PowerFlex storage providing more flexible options for customers.

The following figure highlights applications consuming PowerFlex file storage:

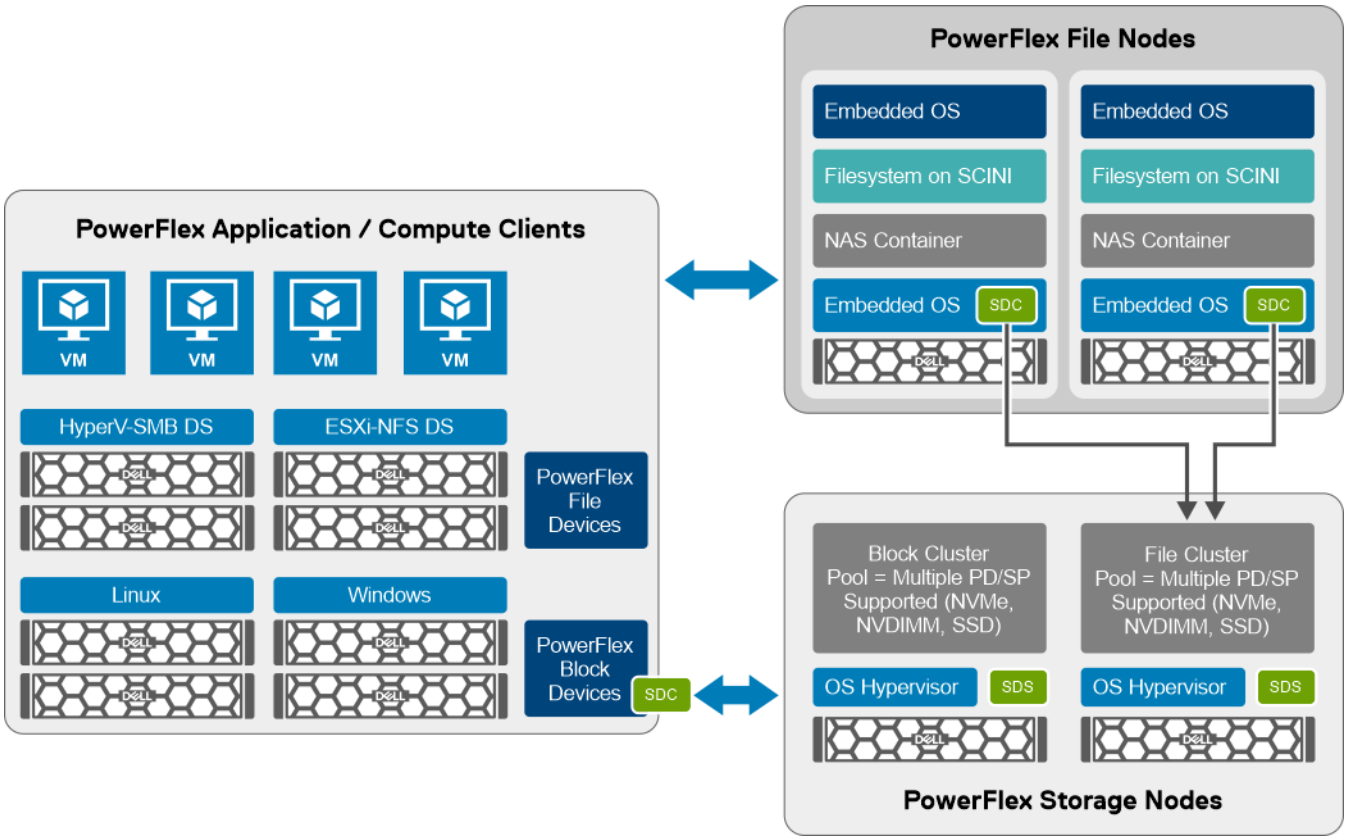


Figure 8. Applications consuming PowerFlex file storage

With the native file capabilities available on PowerFlex rack, administrators can easily implement a highly scalable, efficient, high performance, and flexible solution that is designed for the modern data center. The rich supporting feature set and mature architecture provides the ability to support a wide array of use cases. PowerFlex file uses virtualized NAS servers to enable access to file systems, provide data separation, and act as the basis for multi-tenancy. PowerFlex file services can be accessed through a wide range of protocols and can take advantage of advanced protocol features.

- **PowerFlex file servers** - PowerFlex file uses virtualized file servers that are called NAS servers. A NAS server contains the configuration, interfaces, and environmental information that is used to facilitate access to the file systems. This includes services such as Domain Name System (DNS), Lightweight Directory Access Protocol (LDAP), Network Information Service (NIS), protocols, anti virus, NDMP, and so on.
- **Multi-tenancy** - NAS servers can be used to enforce multi-tenancy. This is useful when hosting multiple tenants on a single system, such as for service providers. Since each NAS server has its own independent configuration, it can be tailored to the requirements of each tenant without impacting the other NAS servers on the same appliance. Each NAS server is logically separated from each other, and clients that have access to one NAS server do not inherently have access to the file systems on the other NAS servers. File systems are assigned to a NAS server upon creation and cannot be moved between NAS servers.
- **High availability** - New NAS servers are automatically assigned across the available nodes. The preferred node acts as a marker to indicate the node that the NAS server should be running on. Once provisioned, the preferred node for a NAS server never changes. The current node indicates the node that the NAS server is running on. Changing the current node moves the NAS server to a different node, which can be used for load-balancing purposes. When a NAS server is moved to a new node, all file systems on the NAS server are moved along with it.
- **Protocols** - PowerFlex file supports SMB1 through 3.1.1. SMB3 enhancements such as continuous availability, offload copy, protocol encryption, multichannel, and shared VHDX in Hyper-V are supported on PowerFlex file. PowerFlex file also supports the Microsoft Distributed File System (DFS) namespace. This ability enables the administrator to present shares from multiple file systems through a single mapped share. PowerFlex file SMB servers can be configured as a stand-alone DFS root node or as a leaf node on an Active Directory DFS root. DFS-R (replication) is not supported on PowerFlex file SMB servers.

  PowerFlex file supports NFSv3 through NFSv4.1 and as Secure NFS. Each NAS server has options to enable NFSv3 and NFSv4 independently. Support for advanced NFS protocol options is also available. NFSv4 is a version of the NFS protocol that differs considerably from previous implementations. Unlike NFSv3, this version is a stateful protocol, meaning that it maintains a session state and does not treat each request as an independent transaction without the need for additional preexisting information NFSv4 brings support for several new features including NFS ACLs that expand on the existing mode-bit-based access control in previous versions of the protocol.

  NAS servers and file systems also support access for FTP and SFTP. SFTP is more secure since, it does not transmit usernames and passwords in clear text. FTP and SFTP access can be enabled or disabled individually at the NAS server level. Only active mode FTP and SFTP connections are supported.

- **Multi-protocol support** - When a NAS server has both the SMB and NFS protocols enabled, multi-protocol access is automatically enabled. Multiprotocol access enables accessing a single file system using the SMB and NFS protocols simultaneously.
- **Naming and directory services** - PowerFlex file supports the following naming and directory services:
  - DNS - A service that provides translations between hostnames and IP addresses
  - LDAP/NIS - Services that provide a centralized user directory for username and ID resolution
  - Local files - Individual files used to provide username and ID resolution
- **Filesystem** - PowerFlex file leverages a 64-bit file system that is highly scalable, efficient, performant, and flexible. The PowerFlex file is mature and robust, enabling it to be used in many of the traditional NAS use cases.
- **Compression** - PowerFlex file supports compression using fine granularity storage pools.
- **Shrink and extend** - PowerFlex file provides increased flexibility by providing the ability to shrink and extend file systems as needed. Shrink and extend operations are used to resize the file system and update the capacity that is seen by the client.
- **Quotas** - PowerFlex file includes quota support to allow administrators to place limits on the amount of space that can be consumed to regulate file system storage consumption. PowerFlex file supports user quotas, quota trees, and user quotas on tree quotas. All three types of quotas can co-exist on the same file system and can be used together to achieve fine grained control over storage usage.
  - User quotas: User quotas are set at a file system level and limit the amount of space a user may consume on a file system. Quotas are disabled by default.
  - Tree quotas: Quota trees limit the maximum size of a directory on a file system. Unlike user quotas, which are applied and tracked on a user-by-user basis, quota trees are applied to directories within the file system. Quota trees can be applied on new or existing directories.
  - User quotas on tree quotas: Once a quota tree is created, it is also possible to create additional user quotas within that specific directory by choosing to enforce user quotas. When multiple limits apply, users are bound by the limit that they reach first.
- **Snapshots** - PowerFlex file features pointer-based snapshots. These can be used for restoring individual files or the entire file system back to a previous point in time. Since these snapshots leverage redirect-on-write on technology, no additional capacity is consumed when the snapshot is first created. Capacity only starts to be consumed as data is written to the file system and changes are tracked.
- **CAVA** - Common Anti-Virus Agent (CAVA) provides an ant virus solution to SMB clients by using third-party anti virus software to identify and eliminate known viruses before they infect files on the storage system. Windows clients require this to reduce the chance of storing infected files on the file system and protects them if they happen to open an infected file.

The CAVA solution is for clients running the SMB protocol only. If clients use the NFS or FTP protocols to create, modify, or move files, the CAVA solution does not scan these files for viruses.

- **NDMP** - PowerFlex file supports three-way Network Data Management Protocol (NDMP) backups, allowing administrators to protect file systems by backing up to a tape library or other backup device. In an NDMP configuration, there are three primary components:
  - Primary system - Source system to be backed up, such as PowerFlex file.
  - Data Management Application (DMA) - Backup application that orchestrates the backup sessions, such as NetWorker.
  - Secondary system - The backup target, such as PowerProtect.

  Three-way NDMP transfers both the metadata and backup data over the network. The metadata travels from the primary system to the DMA. The data travels from the primary system to the DMA and then finally to the secondary system.
- **Global NameSpace** - Global NameSpace also known as single namespace provides users a virtual view of shared folders by grouping shares/exports located on different servers into one or more single entry point to access multiple-filesystems. With Global NameSpace feature enabled, client hosts with correct access permission would be able to access existing and newly added FS to the Global NameSpace without needing to explicitly map/mount it on each client. Powerflex file supports multi-protocol Global NameSpace (GNS) for both SMB and NFSv4 clients. NFSv3 clients are not supported by the Global NameSpace infrastructure however they can access the shares directly.
- **Common Event Publishing Agent (CEPA)** - The Dell Common Event Enabler (CEE) framework is used to provide a working environment for the Common Event Publishing Agent (CEPA) facility, which includes sub-facilities for auditing, content/quota management (CQM), Common Asynchronous Publishing Service (VCAPS), and indexing. CEE Common Event Publishing Agent (CEPA) is a mechanism whereby applications can register to receive event notification and context from Powerflex file system. The event publishing agent delivers to the consuming application both event notification and associated context in one message. Context may consist of file metadata or directory metadata that is needed to decide business policy
- **NAS Server and Filesystem Clone** - Powerflex file users can clone their NAS server and filesystem for environment repurposing.
- **File-level retention** - File-level retention protects files from modification or deletion until a specified retention period. Protecting a file system using File-level retention enables you to create a permanent, and unalterable set of files and directories. File-level retention ensures data integrity and accessibility, simplifies archiving procedures for administrators and improves storage management flexibility.

8

Security considerations

Enterprises have many reasons for encrypting data, including addressing regulatory compliance, protecting against theft of customer data, and sensitive intellectual property.

PowerFlex rack offers numerous built-in security features and capabilities cross multiple security domains to help you meet security and compliance requirements. This section provides a summary of the PowerFlex rack security features by security domains.

Asset management

- PowerFlex Manager simplifies asset discovery and system resources inventory management
- Resource deployment services template and resource tagging allows you to efficiently deploy a complex environment with consistency

Identity authentication and authorization

PowerFlex rack architecture offers built-in security controls to meet authentication and authorization needs. Key security controls are:

- LDAP/active directory integration
- Role-based access control (RBAC)
- RSA SecurID MFA option (using key cloak)

Data confidentiality

Confidentiality is one of the key pillars of the security triad (CIA). PowerFlex rack offers both software and hardware based FIPS 140-2 compliant data at rest encryption. For hardware-based D@RE, you can choose self encrypting drives (SED)s that meet your business needs and use integrated CloudLink for key management. The integrated CloudLink can also be used to provide software-based encryption for PowerFlex storage data servers (SDS) that is transparent to the features and operation of the PowerFlex solution. CloudLink uses dm-crypt, a native Linux encryption package, to secure SDS devices. A proven high-performance volume encryption solution, dm-crypt is widely implemented for Linux machines.

CloudLink encrypts the storage data server devices with unique keys that are controlled by enterprise security administrators. CloudLink Center provides centralized, policy-based management for these keys, enabling single-screen security monitoring and management across one or more PowerFlex deployments.

System trust

PowerFlex rack is built with PowerFlex nodes, which are PowerEdge servers. The PowerFlex nodes inherit all the cutting-edge cyber-resiliency and security features such as:

- An immutable silicon-based root of trust to securely boot iDRAC, BIOS and firmware
- Virtual lock for preventing server configuration/firmware changes and drift detection
- Rapid recovery to a trusted image when authentication fails
- Rollback to known good firmware version if firmware is compromised
- Secure system erase internal server storage devices including HDD, SSD, and NVMe drives
- Industry leading secure supply chain
- PowerFlex software integrity check

Network security

PowerFlex rack not only offers built-in access and aggregation or leaf-spine network topology but also incorporates many advanced security features that are available with Cisco Nexus and Dell PowerSwitch switches. These security features help you to protect network against data loss or compromise resulting from intentional attacks and from unintended but damaging actions made by well-meaning network users. Key security features include:

- Network segmentation with, ACL, firewall, and VLAN
- TACACS+ Security Protocols support
- LDAP authentication and authorization support
- Role-based access control (RBAC) to control and limit access to operations on the Cisco NX-OS device
- Authentication, authorization, and accounting (AAA) an architectural framework support
- Access control list (ACL) support. IP ACLs, MAC ACL and VACL are available options to filter traffic based on IPv4 addresses, MAC address in the packet header, and VLAN routing
- Simple Certificate Enrollment Protocol (SCEP) support
- Dynamic ARP inspection, DHCP Snooping, key chain management, and control plane policing can used to further harden the security

Auditing and accountability

Audit and accountability's primary objectives are to maintain a record of system activities, and provide the ability to establish individual accountability, detect system anomalies, reconstruct system events using audit logs and records. PowerFlex rack creates and retains system audit logs, event logs and alert records to that can be used for monitoring, trend and behavior analysis, incident investigation, and reporting of unlawful or unauthorized system activities.

Physical protection

The PowerFlex rack cabinet has intelligence built-in to provide advanced operational and physical security controls to complement and enhance the data center security posture. Key security features include:

- Integrated HID with keypad reader
- Cabinet access can be configured with multiple authentication methods
- HID card with keypad entry (default)
- HID card entry only
- Keypad entry only
- Actuation door handles
- Security auditing
- Remote lock/unlock capability
- LDAP/AP integration
- Mechanical key

9

Cabinet and intelligent PDUs

The PowerFlex rack cabinet is a custom cabinet designed to meet operational, environmental and security needs of the modern data center.

The cabinet has built-in intelligence that allows you to manage, monitor, and control the physical environment and security controls. Key features include:

- Monitor-thermal, power and security (via SNMP traps) allows you to signal conditions that are out of normal operations via thresholds.
- Understand-environmental data (via SNMP traps) allows use of power and thermal conditions to evaluate peak loads in the cabinet and data center.
- Thermal-air inlet and exhaust temperatures; humidity.
- Power-input power, breaker and outlet usage; outlets have equipment names that allows identification of equipment and power consumed.
- Security-access controls into cabinet, duration of open cabinet, time/date/individual access, and access point.
- Power consumption by individual PDU, circuit and receptacle.
- Provide information upstream for intelligent analytics.
- Improve the physical security of the cabinets.
- Connected to single dashboard control.

Physical build

Table 11. PowerFlex rack physical build

Physical components	Visual representation

• Two cabinet options - 42RU and 48RU
  ○ 700mm x 1200mm x 42RU
  ○ 800mm x 1200mm x 42RU
  ○ 700mm x 1200mm x 48RU
• Advance thermal management ready
  ○ IPI PDU network controller
  ○ Single point of access to information per cabinet
  ○ Daisy chain six PDUs per cabinet
• IPI power distribution unit (PDU)
  ○ PDUs features 36 outlets per unit
  ▪ 12 C19 outlets
  ▪ 24 C13 outlets
• IPI environmental
  ○ Temperature sensors
  ○ Humidity sensors
  ○ Door open/closed sensors
  ○ Door lock/unlock sensors
• IPI security
  ○ Secure door handles with integrated HID w/keypad reader
  ○ Actuation door handles
  ○ Security reporting/auditing
  ○ Remote lock/unlock capability
• Per outlet monitoring and switching
• 2,500 lbs equipment load rating for dynamic shipping per International Safe Transit Association (ISTA-2B and 3H).
	

Table 11. PowerFlex rack physical build

Physical components	Visual representation
• Fully bonded cabinet with optional grounding system • IPI PDU with network controllers installed for single point of access using a graphical user interface	

10

Technology integration

Integrated data protection

This section describes the design of integrated data protection with PowerFlex rack.

There are three main offerings, each focused on one of the integrated data protection solutions that are offered with PowerFlex rack:

- PowerProtect Data Manager with PowerProtect DD backup solution
- PowerProtect Data Manager Appliance
- PowerProtect Cyber Recovery

PowerProtect Data Manager with PowerProtect DD backup solution

PowerProtect Data Manager allows you to protect, manage, and recover data in on-premises, virtualized, or cloud deployments. It enables automated discovery of virtual machines (VMs), databases, centralized protection for databases and containers, and integrated storage. PowerProtect Data Manager supports the following features:

- Integrated deduplication and replication.
- Self-service backup and recovery operations from native applications.
- Multi-cloud optimization with integrated cloud tiering.
- Software as a service-based monitoring and reporting.
- Schedule backups from a central location on the PowerProtect Data Manager server in a large-scale database environment.
- Governed self-service and centralized protection that includes:
  - Monitoring and enforcing service level objectives (SLO).
  - Identifying violations of recovery point objectives (RPO).
  - Applying retention locks on backups that are created using the Microsoft application agent and the Oracle Recovery Manager agent.
- PowerProtect Search enables backup administrators to quickly search and restore file copies. The PowerProtect Search software indexes VM file metadata to enable search. After you add the indexing to protection policies, the assets automatically index as they back up.
- Deploy an external VM direct appliance (vProxy).
- Manual backups of VMs in the VMware vSphere Client.
- Benefits of integrating PowerProtect Data Manager and PowerProtect DD with PowerFlex rack:
  - PowerProtect Data Manager platform provides centralized governance that helps mitigate risk and assures compliance of service-level agreements (SLA) and SLO through protection workflows.
  - Data Domain Boost (DD Boost) protocol provides advanced integration with backup and enterprise applications for increased performance.
  - DD Boost distributes parts of the deduplication process to the backup server or application clients, enabling faster client-side deduplication and a more efficient backup and recovery.

PowerProtect Data Manager Appliance

PowerProtect Data Manager Appliance provides a unified user experience and automates discovery and protection of databases, VMs, file systems and Kubernetes containers.

PowerProtect Data Manager Appliance orchestrates protection directly through an intuitive interface and secure data with the latest capabilities for operational and cyber resilience. PowerProtect Data Manager Appliance empowers data owners to perform self-service backup and restore operations from their native applications with central governance and oversight.

PowerProtect Cyber Recovery

PowerProtect Cyber Recovery provides modern, resilient and intelligent protection to isolate critical data, identify suspicious activity and accelerate data recovery allowing you to quickly resume normal business operations.

PowerProtect Cyber Recovery automates the synchronization of data between production systems including open systems and mainframes, and the vault creating immutable copies with locked retention policies. If a cyberattack occurs you can quickly identify a clean copy of data, and recover your critical systems.

PowerScale

PowerScale is a scale-out NAS storage and powered by OneFS operating system providing scalability, efficiency, high availability, and data protection to the massive unstructured data. This solution delivers increased performance for file-based data applications and workflows from a single file system architecture.

PowerScale provides an extra intelligent storage solution to meet the challenges organizations face as they encounter digital content and unstructured data and the growing importance of data protection. PowerScale is an add-on component that provides scale-out file-based storage capacity to PowerFlex rack. PowerScale can be accessed using NFS, CIFS, and SMB mounted to the VM that is created on PowerFlex rack. The following diagram provides an example logical layout of a PowerFlex rack with PowerScale:

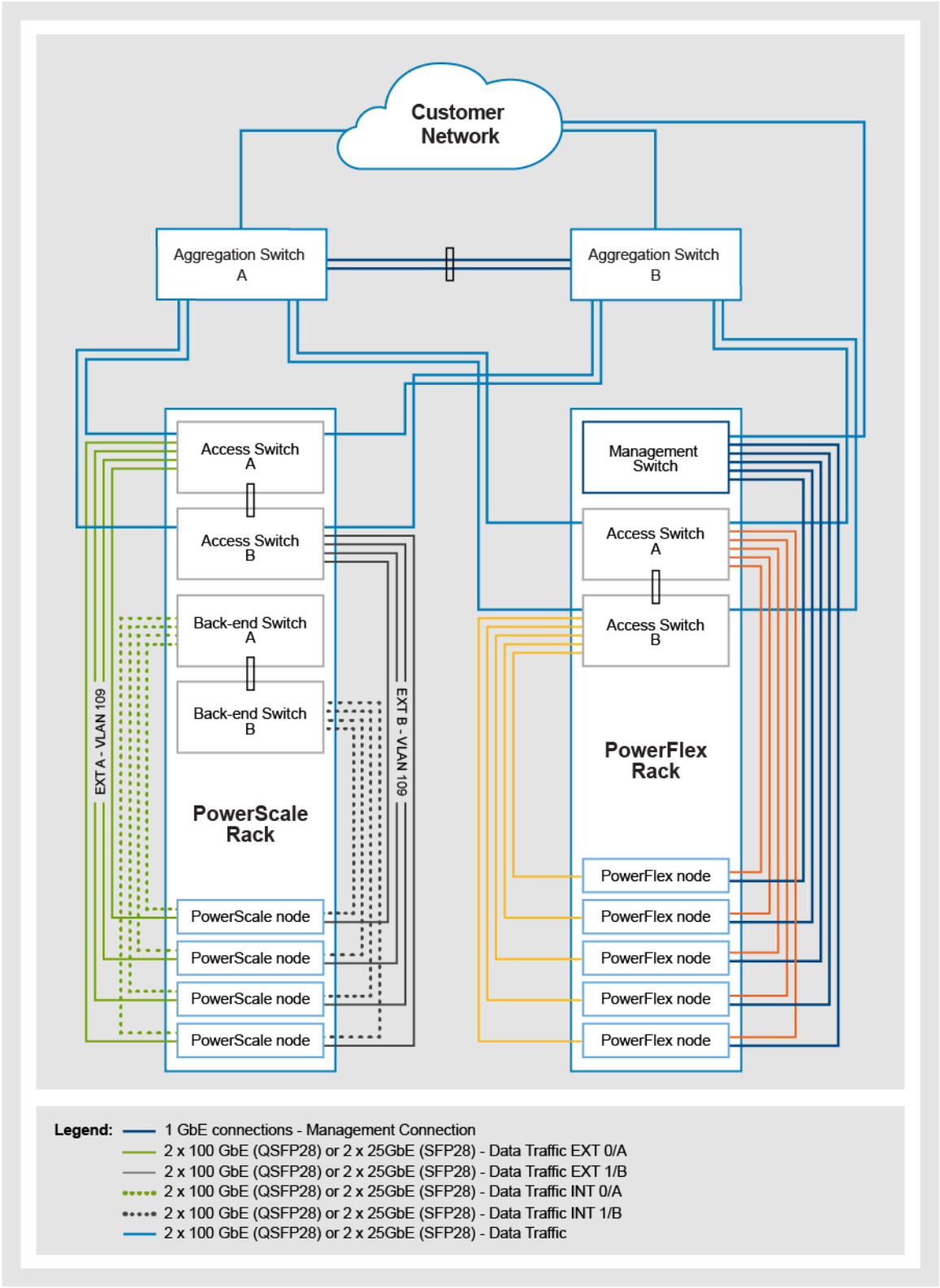


Figure 9. Logical layout of a PowerFlex rack with PowerScale

11

Additional references

This section provides links to related information for network, storage, and virtualization components.

Table 12. Additional reference links

Product	Description	Link to product documentation
PowerFlex	Converges storage and compute resources into a single layer architecture, aggregating capacity and performance, simplifying management, and scaling to thousands of PowerFlex nodes.	Dell PowerFlex
VMware vCenter Server	Provides a scalable and extensible platform that forms the foundation for virtualization management.	VMware vCenter Server
Virtualized infrastructure for PowerFlex	Virtualized infrastructure for PowerFlex rack and PowerFlex appliance. Virtualizes all application servers and provides VMware High Availability (HA) and Dynamic Resource Scheduling (DRS).	VMware vSphere