Reliable Performance at Scale: Dell AX System for Azure Local with PowerFlex

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White Paper

Abstract

The Dell AX System for Azure Local is a Premier Solution for Azure Local offering turnkey infrastructure with native Azure integration. It uniquely supports a disaggregated architecture by combining AX nodes from Dell with Dell PowerFlex block storage, enabling independent scaling, high availability, and workload flexibility. This whitepaper presents performance testing results showing that PowerFlex delivers consistent, near-linear storage scalability across various workloads, making it a compelling solution for optimizing Azure Local deployments.

Dell Technologies Solutions

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Introduction

Managing distributed infrastructure across multiple locations in both public and private clouds—while optimizing performance, scalability, and manageability at scale—is a constant challenge for modern enterprises. The Dell AX System for Azure Local is a continuously validated Premier Solution for Azure Local that provides turnkey, purpose-built hyperconverged infrastructure (HCI) for deploying Azure Local instances on premises with a deeply integrated, Azure-native management experience.

Our performance engineering team thoroughly tested the storage performance and scalability of Dell AX System for Azure Local instances with PowerFlex, using the AX nodes for compute only. This whitepaper presents our performance testing results demonstrating how PowerFlex delivers predictable, consistent, and near-linear storage performance scalability across a variety of synthetic workload profiles and Azure Local instance sizes. These capabilities make it an ideal solution for organizations seeking to optimize and right-size their Azure Local instances and workloads.

Azure Local and PowerFlex Overview

Brief Overview of Azure Local: Extending Azure to the Data Center

Azure Local is Microsoft's on-premises, Azure-connected hybrid infrastructure platform that brings the power of Azure directly into customer data centers by using Azure as the management control plane for distributed infrastructure. It enables organizations to deploy VMs and containers directly to on-premises Azure Local instances via the Azure portal or programmatically and manage them in the same way they manage cloud-native Azure resources, using a substantial subset of the same Azure management, orchestration, governance, and monitoring services and APIs the rest of their Azure resources do. This deep integration with Azure services helps organizations simplify and streamline operations, provides operational consistency across hybrid cloud environments, and offers unique and differentiated value for customers who want to optimize their Azure-native hybrid cloud platform deployments and workloads, especially in industries where data sovereignty or regulatory compliance imperatives necessitate strict control over data locale or the use of private cloud infrastructure.

Azure Local uses Storage Spaces Direct (S2D) as its default software-defined storage solution. S2D pools local storage across multiple servers to create a highly available cluster storage system. While this paper focuses on PowerFlex for VM and workload storage, it's important to note that S2D remains active on all Azure Local instances.

Azure Local is particularly well-suited for organizations that require or could benefit from:

- Support for diverse workloads, including traditional enterprise applications, containerized services, and virtual desktop infrastructure (VDI)
- Strict control over data residency and sovereignty, ensuring that sensitive data remains on premises to meet regulatory and compliance requirements
- Resilience for workloads in limited-connectivity environments where continuous cloud access cannot be guaranteed
- Centralized provisioning and management of distributed infrastructure across multiple sites through a single Azure portal-based control plane using Azure Arc, Azure Resource Manager, and Azure APIs
- Deep integration with Azure-native management, orchestration, monitoring, and governance services including Azure Kubernetes Service, Azure Update Manager, Azure Policy, Azure Monitor Insights, Microsoft Defender for Cloud, and Azure Migrate

About the Dell AX System

The Dell AX System for Azure Local is a Microsoft Premier Solution that delivers continuously validated, purpose-built hyperconverged infrastructure optimized for use in Azure Local instances. Developed through extensive engineering collaboration between Dell and Microsoft, the Dell AX System is preconfigured for Azure Local and includes Dell's enterprise support and services portfolio for the entire end-to-end solution—including deployment, configuration, management, and maintenance—from dedicated Dell AX System and Azure Local experts. As one of very few Premier Solutions for Azure Local—Microsoft's highest tier of Azure Local certified solutions—the Dell AX System is a turnkey solution that provides a seamless, Azure-native provisioning and management experience for hosting on-premises Azure Local virtual machines and containers.

Each AX node is preconfigured and optimized to support Azure Local and is registered with Azure Arc to enable centralized management through the Azure portal. Dell enhances this experience with deployment, automation, and orchestration capabilities that extend Microsoft-native tooling, including Dell OpenManage integration for Microsoft Windows Admin Center, which simplifies provisioning, governance, monitoring, and lifecycle management operations across the full hardware and software stack.

Dell AX System for Azure Local solutions are available via both OpEx- or CapEx-based billing and licensing models; customers can choose between a one-time-payment OEM license and an ongoing subscription-based billing model licensed per physical core. Customers with existing active Windows Server 2025 Datacenter core licenses and Software Assurance can also exchange those licenses for equivalent Azure Local core licenses. The one-time, pre-installed OEM license for Azure Local covers up to 16 cores (with add-on licenses available for systems with higher core counts), remains valid for the lifetime of the hardware, and includes ongoing access to Azure Local, Azure Kubernetes Service (AKS) on Azure Local enabled by Azure Arc with unlimited containers, and unlimited Windows Server 2025 Datacenter guest VMs.

Dell AX System appliances are available in a variety of PowerEdge-based configurations that enable organizations to right-size their Azure Local infrastructure for any type of workload (see Tables 1 and 2 for examples). For more information, read the Dell AX System for Azure Local solution brief, take a look at the spec sheet, or view the Azure Local Premier Solutions catalog.

Together, Dell AX System and Azure Local provide a robust, scalable foundation for hybrid infrastructure in distributed environments that unifies deployment, management, and governance of VMs and containers hosted both on-premises and in the Azure cloud and provides end-to-end lifecycle management and enterprise-grade support for the entire solution stack.

Table 1. Dell AX-660 base configuration options.

Configuration name	Single-machine support*	Storage type	Min storage	Max storage	Min cores	Max cores	Min RAM	Max RAM
Dell AX-660 All-Flash (All-NVMe®)	Yes	NVMe	1.92 TB	153.6 TB	8	36	128 GB	8 TB
Dell AX-660 All-Flash (SSD)	Yes	SSD	1.6 TB	76.8 TB	8	36	128 GB	8 TB

*Clusters with a single machine can use only one storage type (NVMe or SSD).

Table 2. Dell AX-660 configuration options.

Storage Configuration	All Flash (All SSD)	All Flash (All NVMe)
Chassis Configurations	• 10x 2.5" SAS Chassis • Up to 10x SSD front drives (SAS/vSAS)	• 10x 2.5" SAS Chassis • Up to 10x NVMe front drives
Processors	Two 4th Gen (Sapphire Rapids) or 5th Gen (Emerald Rapids) Intel® Xeon® Scalable processors with up to 36 cores per processor	
Memory	128 GB to 8 TB (Up to 32x DR5 RDIMMs, speeds up to 5,600 MT/s)	
Storage Controller	Internal HBA 355i 12Gbps SAS HBA Controller (NON-RAID)	None
Storage - OS Boot	BOSS N1 with dual hot-plug 960GB M.2 NVMe disks in RAID 1	
Drive Count and Storage for Capacity Min/Max	• Minimum: 2x 800 GB = 1.6 TB • Maximum: 10x 76.8 TB = 76.8 TB	• Minimum: 2x 960 GB = 1.92 TB • Maximum: 10x 15.36 TB = 153.6 TB
Network Cards	• PCIe (required): 1-3 • OCP 3.0 (optional) • Integrated LOM: 2x 1GbE Broadcom 5720 (used for factory imaging only, not supported for customer use cases) • Vendors: Broadcom, Intel and NVIDIA • Port Count: Dual-port and quad-port • Operational Speeds: 10, 25, and 100GbE • RDMA Protocol Support: IWARP, RoCE	
GPU DW = Double Wide SW = Single Wide	GPU capable of up to 2x SW GPU • NVIDIA Ampere A2 SW, PCIe, 60W, 16GB Passive • NVIDIA Ada Lovelace, L4, SW, 72W, 24GB Passive	
Operating System	Latest Azure Local golden image from Dell Technologies available from the Support Matrix	
Out of Band Management	Integrated Dell Remote Access Controller (IDRAC) 9 Enterprise or Datacenter IPMI 2.0 compliant	
Integrations	Dell OpenManage Integration with Microsoft Windows Admin Center v3.3.2 or higher can be used with Windows Admin Center installed locally on premises or Windows Admin Center in the Azure portal	
Services	ProDeploy, ProDeploy Plus, ProSupport, ProSupport Plus, optional Dell Infrastructure and Consulting services Call-routing, phone home, remote support, and automated case creation supported with Secure Connect Gateway	
Security	Trusted Platform Module 2.0	
Power Supplies	Dual, Hot-plug, Redundant Power Supply (1+1); 1,100/1,400/1,800 W	
Form Factor	1U rack	
PowerFlex Integration	If connecting to a PowerFlex Cluster, refer to the Design Guide	

PowerFlex and Disaggregated Infrastructure for Azure Local

Combining the Dell AX System for Azure Local with Dell PowerFlex enables customers to move beyond traditional hyperconverged infrastructure by adopting a disaggregated infrastructure architecture that allows them to scale compute and storage resources independently. This architecture is particularly valuable for organizations with dynamic or large-scale workloads—such as such as VDI, OLTP, AI/ML, and analytics—especially on larger Azure Local instance sizes, that require high operational consistency, availability, scalability, and performance. It also enables enterprises to leverage any existing PowerFlex investments in their datacenters and streamlines operations by consolidating diverse multiplatform workloads onto a single, unified, and massively scalable storage platform.

While most Azure Local solutions use the default Storage Spaces Direct configuration, Dell is the only OEM to offer external block storage for Azure Local instances via PowerFlex integration. This allows one or many Azure Local instances to consume storage from an independent PowerFlex cluster, which provides several advantages:

- Independent scaling of compute and storage to optimize infrastructure based on workload demands without the constraint of tightly coupled HCI architecture
- A universal shared storage layer spanning both datacenter and cloud that can be utilized by multiple Azure Local instances as well as other datacenter infrastructure
- Consistent, near-linear storage performance scaling with Azure Local, as validated by our internal performance testing that shows predictable IOPS growth as Azure Local instance sizes increase
- High availability and reliability for mission-critical workloads, with six-9s (99.9999%) uptime availability
- Massive scalability, thanks to PowerFlex's modular architecture and robust storage performance

Read more about how to unlock the full potential of your hybrid cloud infrastructure by combining Dell AX System for Azure Local and Dell PowerFlex in the solution brief.

Performance Testing

Introduction

One of the standout benefits of using PowerFlex for your Azure Local instance storage is its predictable and near-linear scalability across diverse workload profiles. The performance engineering team at Dell Technologies spent considerable time testing the scalability of a Dell AX System for Azure Local instance with PowerFlex external block storage using VMFleet, Microsoft's standard storage performance benchmarking tool. In this section, we provide details about the lab infrastructure, testing methodology, and results of that testing.

Test Environment and Node Specifications

Lab Infrastructure: AX Node Models and Hardware Configurations, NICs, Drives, OS Versions

We performed tests using Azure Local instances running MC-660 nodes in the Dell Cloud Platform for Microsoft Azure (equivalent to AX-660 nodes running in the Dell AX System) for compute and a Dell PowerFlex cluster built with PowerFlex Appliance R660 S nodes for storage. Both nodes are based on the PowerEdge R660 platform and are configured with dual 100GbE network interfaces. It is important to note that while testing was performed on MC-660 nodes using the Dell Cloud Platform for Microsoft Azure, the underlying solution stack both in terms of hardware and software is largely identical to the Dell AX System for Azure Local, its successor. Tables 3 and 4 present detailed specifications for both cluster nodes.

Table 3. Configuration details of Azure Local machines.

Component	Details	Comments
Server Model	Dell Cloud Platform MC-660	Based on Dell PowerEdge R660
CPU Model	2x Intel Xeon Gold 6430	32 Cores/CPU
Memory	512GB DDR5 4,400MT/s	32GB DIMMs
Embedded NIC1	Broadcom NetXtreme Gigabit Ethernet (BCM5720)	Not used
Integrated NIC1	NVIDIA ConnectX-6 Lx 2x 25G SFP28	
NIC Slot 1	NVIDIA Mellanox ConnectX-6 Dx Dual Port 100 GbE QSFP56 Adapter	RDMA enabled
NIC Slot 2	NVIDIA Mellanox ConnectX-6 Dx Dual Port 100 GbE QSFP56 Adapter	RDMA enabled
Drives/Server	10	
Drive Model & Size	Dell Ent NVMe CM7 U.2 MU 1.6TB	
OS	Azure Local	10.0.25398 Build 25398 (64-bit)
S2D Fault Tolerance	3-Way Replication	1x 4TB CSVFS_ReFS volume per machine

Table 4. Configuration details of PowerFlex nodes.

Component	Details	Comments
Server Model	PF Appliance R660 S	Based on Dell PowerEdge R660
CPU Model	Intel Xeon Gold 6426Y	16 Cores/CPU
Memory	512GB DDR5 4,800 MTs/	32GB DIMMs
Embedded NIC1	Broadcom NetXtreme Gigabit Ethernet (BCM5720)	Not used
NIC Slot 1	NVIDIA Mellanox ConnectX-6 Dx Dual Port 100 GbE QSFP56 Adapter	
NIC Slot 2	NVIDIA Mellanox ConnectX-6 Dx Dual Port 10 GbE QSFP56 Adapter	
Drives/Server	10	
Drive Model & Size	Dell Ent NVMe PM1735a MU 1.6TB	
OS	PowerFlex OS	
Storage Details	1x 4TB CSVFS_ReFS volume presented to each node	Number of 4TB volumes scales with node count, e.g., 8x 4TB volumes for an 8-node cluster, 10x for a 10-node cluster, etc.

In our testing, we scaled both the Azure Local instance size and the PowerFlex cluster size incrementally from 4- to 12-node configurations and used VMFleet to test storage performance based on a set of synthetic storage workload profiles that simulate common real-world workload types.

Benchmarking with VMFleet 2.1.0

VMFleet is Microsoft's in-house synthetic storage load generator, designed to stress-test and benchmark storage performance. It deploys a "fleet" of VMs and runs a series of DISKSPD 2.2.0 commands to generate multi-threaded storage I/O that simulates various types of real-world workloads while measuring storage IOPS, latency, and throughput as well as CPU and memory utilization. Each VMFleet test deploys a set of VMs, runs DISKSPD commands to simulate the workload profiles under test, and then deletes the VMs to ensure subsequent tests are unaffected by previous test runs.

VMFleet includes a command called Measure-CoreFleetWorkload designed to generate storage load for four predefined workload profiles with various parameters meant to simulate real-world workloads. These workload profiles target different thread counts, block sizes, queue depths, and ratios of read/write and sequential/random storage IO:

- **General:** simulates a general-purpose mixed workload
- **Peak:** maximizes IOPS without consideration for latency or CPU utilization
- **VDI:** simulates a conventional virtual desktop infrastructure workload hosting remote desktop environments
- **SQL:** simulates an OLTP and log-intensive transactional database workload

Table 5 presents details on the specific parameters for each workload profile.

Table 5. Workload profile parameters used in testing.

	General	**Peak**	**VDI:** Read target	**VDI:** Write target	**SQL:** OLTP target	**SQL:** Log target
Thread count	1	4	1	1	4	2
Block size	4K	4K	8K	32K	8K	32K
Queue depth	32	2	8	8	8	1
Write ratio	0/10/30%	0%	0%	100%	30%	100%
Random/sequential ratio	0/100%	100%/0	80/20%	80/20%	100/0%	0/100%

Test Parameters

We tested the four core workload profiles above in a variety of configurations to validate PowerFlex storage performance across different cluster sizes. We started at 4 nodes (in both the Azure Local instance and PowerFlex storage cluster) and scaled both the compute and storage clusters in 1-node increments up to a 12-node configuration. For each instance size, we ran tests with 20 and 32 VMs. Note that while we tested Azure Local instance sizes up to only 12 machines, Azure Local supports up to 16-machine instance configurations. We would expect the same near-linear IOPS trend we see in our testing from 4- to 12-machine instance sizes to continue up to 16 machines.

Environment and Testing Diagram

Figure 1 provides a diagram of our test process. We tested Azure Local instances connected to PowerFlex clusters starting at 4 nodes each and scaled both clusters concurrently up to a total of 12 Azure Local nodes and 12 PowerFlex nodes, with each iteration adding one Azure Local node and one PowerFlex storage node with a corresponding storage volume. The internal S2D configuration remained at its minimum of 2 drives and was not used for workload testing while the PowerFlex nodes were each fully populated with 10 drives. The Azure Local instance and PowerFlex cluster both used dual 100GbE NICs to ensure minimal network performance impact on the results.

Note that we had to rebuild our Azure Local instance twice during testing, once at the 5-machine stage and once at the 9-machine stage. Our results represent the total storage IOPS across the entire cluster.

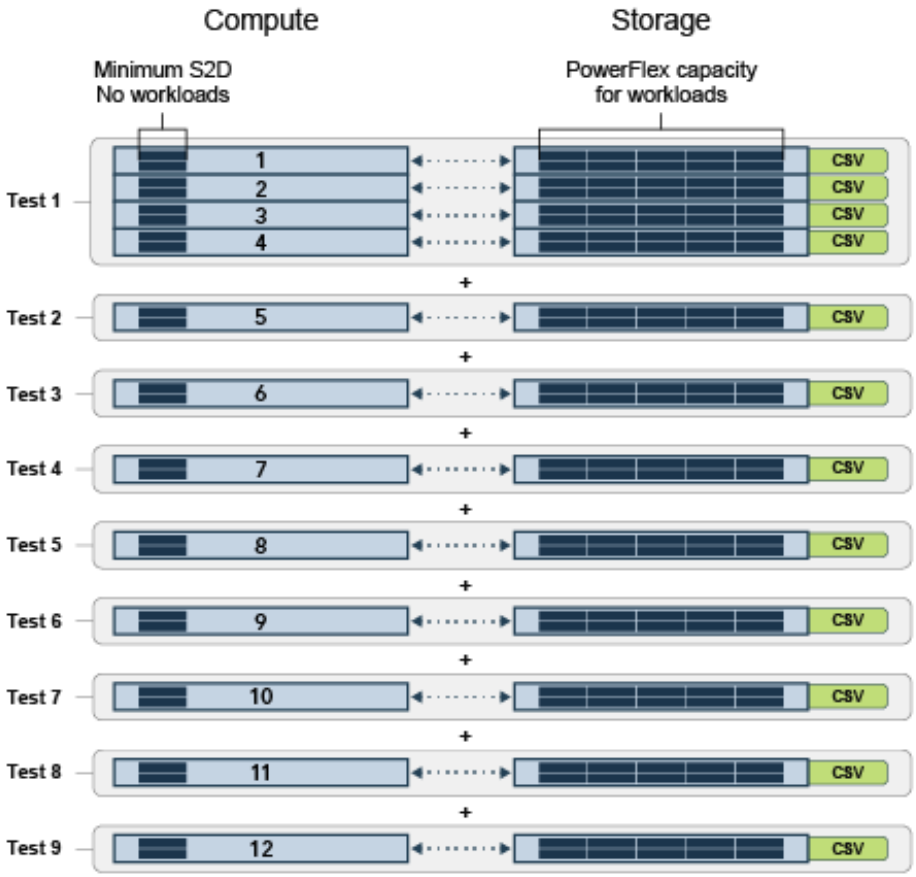

Figure 1. The test environment and process.

Performance Testing Results

Figures 2 through 5 present the storage performance in total cluster IOPS across all four VMFleet core workload profiles as the node counts of the Azure Local instance and corresponding PowerFlex cluster increased, showing both 20 and 32 VM test results. As nodes are added to the PowerFlex cluster and machines to the Azure Local instance, the storage performance trend is consistent and strongly linear, with minimal degradation in performance as across any of the synthetic workloads tested.

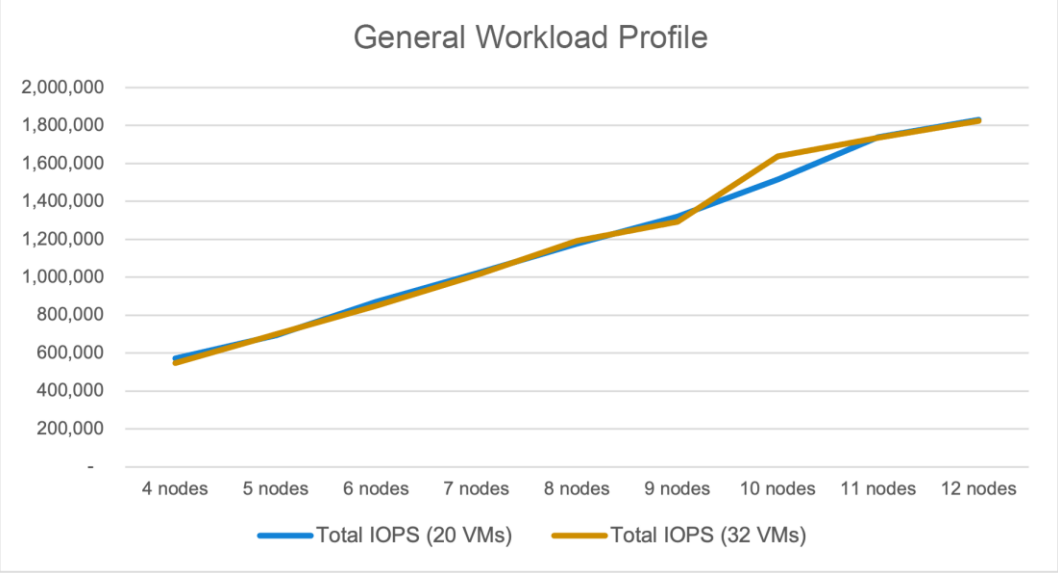

Figure 2. Test results on the General workload profile.

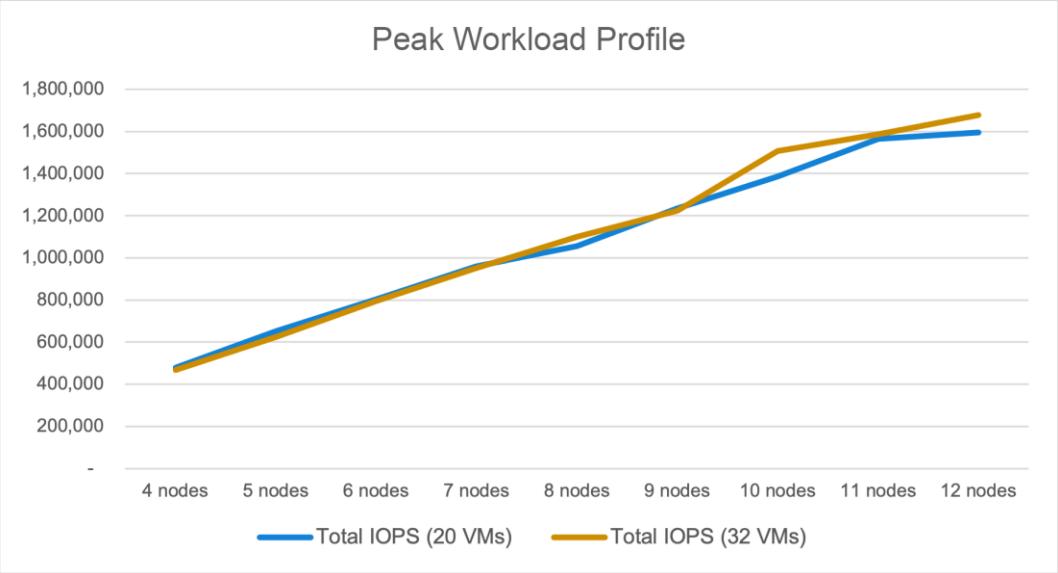

Figure 3. Test results on the Peak workload profile.

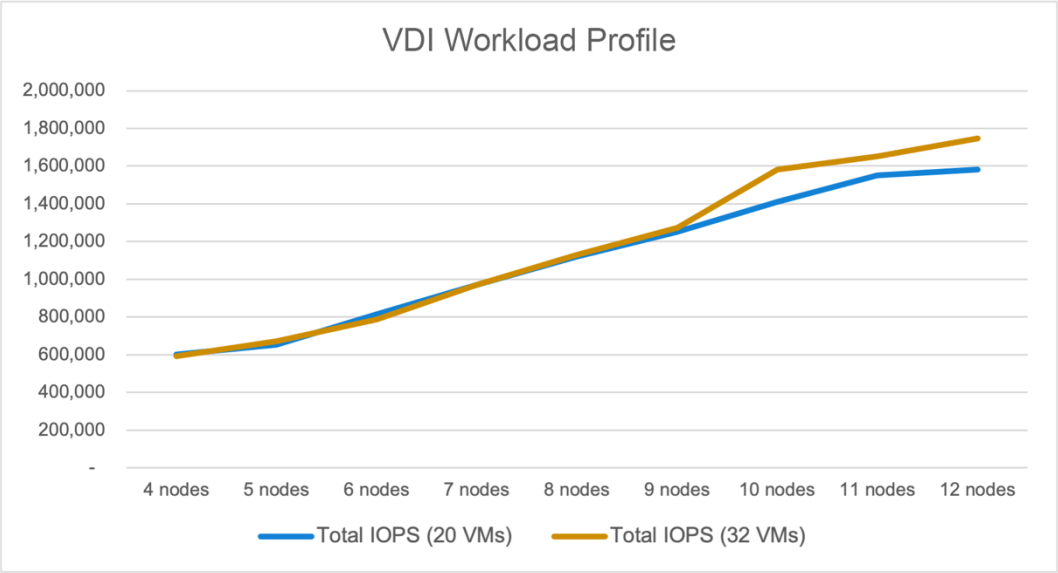

Figure 4. Test results on the VDI workload profile.

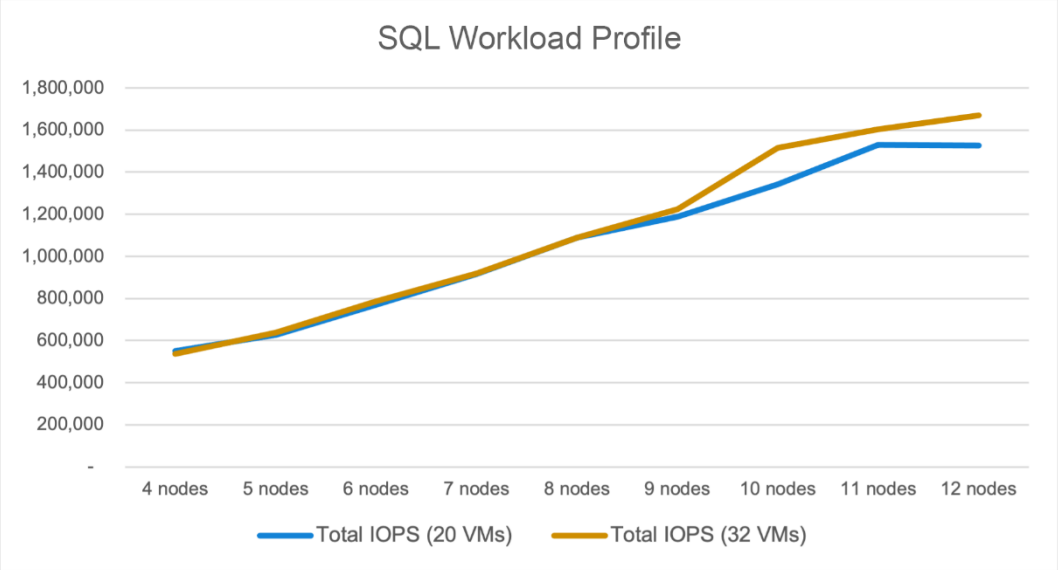

Figure 5. Test results on the SQL workload profile.

In almost all cases, storage performance in total IOPS scaled consistently and linearly as the node counts increase in both the Azure Local instance and PowerFlex cluster. There was little evidence of bottlenecking, even in larger instance sizes, although we did see a limited amount of performance degradation at the highest number of nodes. This kind of consistency and predictability allows you to save by right-sizing your compute and storage when planning application deployments or scaling out your physical infrastructure.

We also measured cluster CPU utilization and noted relatively low CPU overhead, with a representative 10-machine Azure Local instance utilizing less than approximately 20 percent of CPU resources across the entire battery of workload profile tests (see Figure 6). This is notable because in a traditional hyperconverged infrastructure solutions with software-defined storage such as Storage Spaces Direct, the nodes are also responsible for all compute overhead related to storage operations. Consequently, they may incur higher CPU overhead on an Azure Local instance under heavy load than the disaggregated architecture with PowerFlex storage, which has its own separate compute resources.

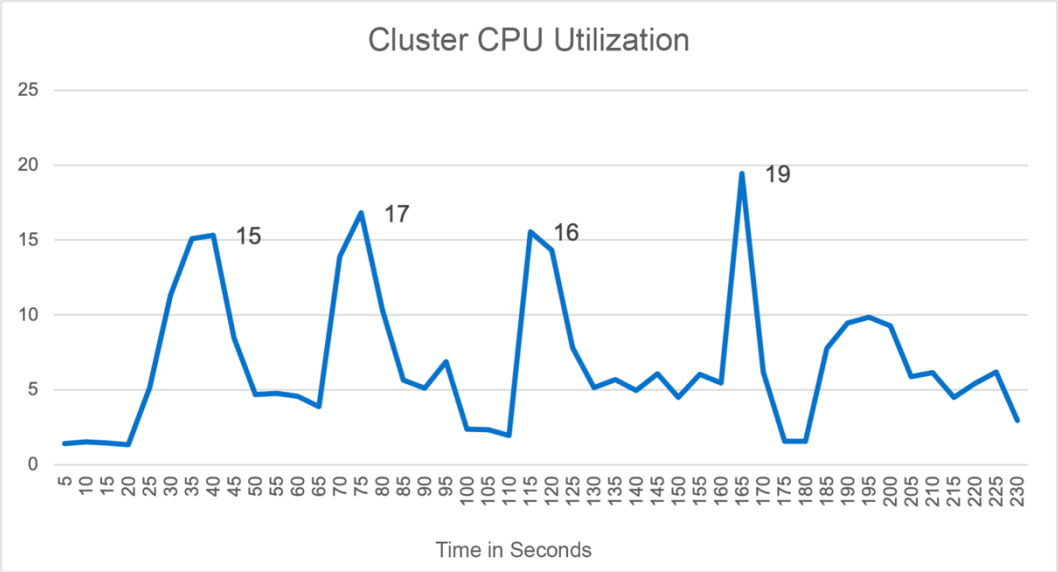

Figure 6. Cluster CPU utilization for a full 20 VM 4-profile core workload performance test suite on a 10-node Azure Local instance with PowerFlex.

Conclusion

Dell AX System for Azure Local with Dell PowerFlex disaggregated storage infrastructure offers a powerful, flexible, and scalable solution for organizations looking to streamline operations across the hybrid cloud. Our internal performance testing shows that PowerFlex enables near-linear, consistent scalability of IOPS and storage performance as Azure Local instance sizes increase from 4 to 12 machines, with low CPU overhead even at peak load. Decoupling compute and storage resources also allows organizations to scale them independently and optimize for workload-specific requirements. Whether supporting large-scale VDI, transactional databases, or mixed enterprise workloads, the Dell AX System for Azure Local with PowerFlex provides the performance, manageability, and resiliency required for modern hybrid cloud and distributed infrastructure architectures.

Seeing is believing. Dell encourages organizations to consider a proof of concept (POC) engagement with a Dell Customer Solution Center or an on-premises Try ‘n Buy.

We Value Your Feedback

Dell Technologies and the authors of this document welcome your feedback on the solution and the solution documentation. Contact the Dell Technologies Solutions team by email.

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Note: For links to additional documentation for this solution, see AX System for Azure Local and Dell AX solutions for Microsoft.