SOLUTION BRIEF

Intel® Select Solutions | Version 2
Modernizing Enterprise Data Center on Hybrid Cloud
2nd Generation Intel® Xeon® Scalable Processors
May 2019

Intel® Select Solutions for Microsoft Azure Stack HCI*

Simplify implementation of Windows Server* hyperconverged infrastructure with Storage Spaces Direct* for efficiency and high performance in the data center and at the edge.

In the enterprise data center and at edge locations, IT organizations in distributed businesses are trying to modernize their infrastructures. Their primary goal at the edge is to deploy low-maintenance, easy-to-manage infrastructure for data collection and local processing without the need to constantly transfer data to and from the data center.

Currently, IT organizations meet that goal by installing several dedicated devices at each site, such as storage-area network (SAN) or network-attached storage (NAS) devices, and the servers and switches they require. While that approach meets the organizations' infrastructure needs, it can result in more assets to manage and a higher total cost of ownership (TCO). IT organizations' longer-term goal, therefore, is to put in place a more-modern, scalable IT model like hyperconverged infrastructure (HCI) at the edge, rather than to simply buy dedicated devices.

Enter Intel® Select Solutions: verified hardware and software stacks, workload-optimized across compute, storage, and networking resources. Intel Select Solutions are ideal for small deployments at the edge, and they are also designed for the scale required in the data center. Built on 2nd Generation Intel® Xeon® Scalable processors, Intel Select Solutions help ensure enterprises get the scalability and performance they require.

Intel Select Solutions for Microsoft Azure Stack HCI* were formerly known as Intel Select Solutions for Windows Server* Software Defined. In addition to the name change, the solutions have been updated with 2nd Generation Intel Xeon Scalable processors.

Azure Stack HCI

To simplify the adoption of hyperconverged infrastructure, Microsoft offers Microsoft Azure Stack HCI, which is designed to ensure that customers have a seamless deployment and steady-state operational experience on validated hardware.

Storage Spaces Direct* is the storage layer of Azure Stack HCI. Storage Spaces Direct extends the software-defined storage stack in Windows Server to offer greater scalability and fault tolerance at lower cost than SAN or NAS. It enables software-defined storage from locally attached, industry-standard flash and hard drives by grouping their capacity into a storage pool that appear to Windows* as regular disks.

Storage Spaces Direct is designed for high performance through built-in read/write caching and support for NVM Express* (NVMe*) and persistent memory. IT organizations can use deduplication, compression, and intelligent storage tiering to save space. They can simplify the management of their hyperconverged infrastructures with Storage Spaces Direct using the same Microsoft tools, such as Windows Admin Center, that they already use for managing virtual machines (VMs).

Intel and Microsoft jointly co-engineer optimizations for Windows Server 2019. The kernel, storage stack, memory manager, Microsoft Hyper-V*, Storage Spaces Direct, and networking components of the operating system work harmoniously with Intel®-based hardware such as the 2nd Generation Intel Xeon Scalable processor platform, Intel® Optane™ DC persistent memory, and Intel® Solid State Drive (SSD) technology. The result is high performance and compatibility without the need for special drivers and software. Hyper-V and Storage Spaces Direct , in conjunction with Internet Wide Area RDMA Protocol (iWARP)-enhanced networking, are the base layers in Windows Server 2019 that provide the foundation for Azure Stack HCI.

Intel Select Solutions for Microsoft Azure Stack HCI

The solutions combine Intel-based hardware with Microsoft Azure Stack HCI to form the basis for simplified, low-cost, hyperconverged infrastructure. They include reference designs tailored to the different compute, memory, and storage needs at the edge and in the data center. They are engineered to help IT organizations optimize price/performance and move to hyperconverged infrastructure while significantly reducing evaluation time.

In 2019, Intel and Microsoft created a second version of the Intel Select Solutions for Microsoft Azure Stack HCI. These solutions feature Microsoft software with the 2nd Generation Intel Xeon Scalable processor platform, Intel Optane DC persistent memory, Intel SSD technology, and Intel® Ethernet Connections. They offer:

- **A modern IT model** for hyperconverged infrastructure with scalable storage and compute
- **Performance verified to meet benchmarks** for Windows Server 2019 Datacenter and Azure Stack HCI, running on trusted Intel architecture
- **More memory per node** with Intel Optane DC persistent memory, at a cost similar to DDR4 DRAM systems
- **End-to-end protection** with the hardware and operating system working together, providing greater security from boot within virtualized workloads and efficient key and data protection at rest[1]
- **Shorter time to value** with a tested, validated solution for compute and software-defined storage

By enabling scaling of storage, compute, and memory, Intel Select Solutions for Microsoft Azure Stack HCI are ideal for applications in areas such as database management, analytics, and enterprise resource planning (ERP).

What Are Intel® Select Solutions?

Intel Select Solutions are pre-defined, workload-optimized solutions designed to minimize the challenges of infrastructure evaluation and deployment. Solutions are validated by OEMs/ODMs, certified by ISVs, and verified by Intel. Intel develops these solutions in extensive collaboration with hardware, software, and operating system vendor partners and with the world's leading data center and service providers. Every Intel Select Solution is a tailored combination of Intel® data center compute, memory, storage, and network technologies that delivers predictable, trusted, and compelling performance.

To qualify as an Intel Select Solution, solution providers must:

1. Meet the software and hardware stack requirements outlined by the solution's reference-design specifications
2. Replicate or exceed established reference-benchmark test results
3. Publish a solution brief and a detailed implementation guide to facilitate customer deployment

Solution providers can also develop their own optimizations in order to give end customers a simpler, more consistent deployment experience.

Hardware Selections

Intel Select Solutions for Microsoft Azure Stack HCI are designed for high performance, easy scalability, and suitability to varied workloads in the data center and at the edge.

Intel® Xeon® Gold Processors

Intel Xeon Gold processors provide an excellent performance-to-cost ratio and the agility and security that enterprises require. Specifically, Intel selected the Intel Xeon Gold 6230 processor and the Intel Xeon Gold 6252 processor to power Intel Select Solutions for Microsoft Azure Stack HCI. The processors enable data services like deduplication and compression, offered in Windows Server 2019, and they offer improved TCO by handling more VMs through their support for more than 2 terabytes of Intel Optane DC persistent memory.[2]

2nd Generation Intel Xeon Scalable processors include hardware-enhanced security capabilities, such as mitigations for the Spectre and Meltdown vulnerabilities, and they build upon the foundation of manageability and virtualization controls.

For applications requiring extra performance, Intel Xeon Platinum processors are available in Intel Select Solutions for Microsoft Azure Stack HCI (see the "Intel Select Solutions for Microsoft Azure Stack HCI—Premium Model" sidebar).

Intel® Optane™ DC Technology

Intel Optane DC technology fills critical gaps in the storage and memory hierarchy, accelerating data access in the data center. This technology also disrupts the traditional memory and storage tiers, offering persistent memory, large memory pools, and fast caching and storage in a variety of solutions.

Intel Optane DC Persistent Memory

As part of the Intel Select Solutions for Microsoft Azure Stack HCI, persistent memory offers the advantage of retaining data through a restart of an in-memory database or of the entire system. It also offers high density—up to 512 GB per module—for a lower cost per gigabyte of memory than that of traditional DRAM DIMMs. Persistent memory complements Storage Spaces Direct by enabling workloads that demand more memory and input/output (I/O).

An important feature of Intel Optane DC persistent memory is its operating modes, which determine the capabilities of memory that are active and available to software.

- **Memory Mode**—Intel Optane DC persistent memory provides a larger pool of volatile memory. The main advantage of Memory Mode is that it offers more capacity than DRAM at a lower price per GB. Also, applications do not need to be modified to benefit from it.
- **App Direct Mode**—In-memory databases, in-memory analytics frameworks, and ultrafast storage applications generally benefit from using App Direct Mode. This mode requires support from the operating system and virtualization environment, so applications are modified to take advantage of it. Persistence through restart is available in App Direct Mode, and storage caching can be moved to this layer from traditional drives for faster performance.
- **Dual Mode**—A configurable percentage of Intel Optane DC persistent memory is dedicated to App Direct Mode, with the remainder available in Memory Mode.

In the Intel Select Solutions for Microsoft Azure Stack HCI, Intel Optane DC persistent memory can improve the performance of the storage subsystem, freeing up cycles for the processor to perform more tasks. It can also result in up to 35 percent lower TCO than for a standard DDR4 system by increasing the density of VMs and containers running in the same physical memory space.[3] With the cost of 512 GB of Intel Optane DC persistent memory on par with the cost of 384 GB of DDR4 RAM, IT organizations can enjoy one-third more addressable memory for more VMs, bigger VMs, and larger memory workloads.[4]

Intel Optane DC SSDs

Intel Optane DC SSDs enable an entirely new storage tier between Intel Optane DC persistent memory and NAND SSDs that brings data closer to the processor for fast caching or fast storage of hot and warm data.

Intel® Xeon® Scalable Processors

2nd Generation Intel Xeon Scalable processors:

- Offer high scalability that is cost-efficient and flexible, from the multi-cloud to the intelligent edge
- Establish a seamless performance foundation to help accelerate data's transformative impact
- Support breakthrough Intel® Optane™ DC persistent memory technology
- Accelerate artificial-intelligence (AI) performance and help deliver AI readiness across the data center
- Provide hardware-enhanced platform protection and threat monitoring

Intel® Select Solutions for Microsoft Azure Stack HCI* feature Intel Xeon Gold processors and Intel Xeon Platinum processors.

Intel Select Solutions for Microsoft Azure Stack HCI use the Intel Optane SSD DC P4800X in the caching tier. The SSD is a good fit for write-intensive uses, such as online transaction processing (OLTP), high-performance computing (HPC), and data caching and logging.

Intel® 3D NAND Technology

Intel® 3D NAND technology–based SSDs deliver performance, quality of service (QoS), and larger capacity to further optimize storage efficiency. They enable data centers to do more per server, minimize service disruptions, and manage efficiently at scale. Intel 3D NAND technology extends leadership in flash memory with an architecture designed for higher capacity and optimal performance, in addition to a proven manufacturing process providing accelerated transitions and scaling.

Intel® SSD Data Center Family

For fast and reliable performance in the enterprise data center, Intel Select Solutions for Microsoft Azure Stack HCI use Intel SSD DC P4510 and Intel SSD DC P4610 drives for capacity. Intel SSDs provide superior performance and outstanding quality, reliability, advanced manageability, and serviceability to minimize service disruptions.

Intel® Ethernet Connections

Intel Select Solutions for Microsoft Azure Stack HCI feature the Intel® C620 Series Chipset with Intel® Ethernet Connection X722 for 10GBASE-T series for a fast Ethernet connection using iWARP-capable network adapters for intelligence and performance in network packet processing. Intel Ethernet Connections feature flexible, scalable I/O virtualization and intelligent offloads to improve performance.

For efficient data transfer, Intel Select Solutions take advantage of Remote Direct Memory Access (RDMA), a technology in Windows Server for high data throughput, low-latency workloads, and low CPU utilization. RDMA allows computers in a network to exchange data in main memory without involving the processor, cache, or operating system of any other computer in the network.

The 10Gb Intel® Ethernet 700 Series Network Adapters with iWARP RDMA accelerate the performance of Intel Select Solutions for Microsoft Azure Stack HCI. Paired with 2nd Generation Intel Xeon Platinum processors, they provide up to 1.6x performance compared to 1Gb Ethernet.[5,6] The Intel Ethernet 700 Series delivers validated performance ready to meet high-quality thresholds for data resiliency and service reliability with broad interoperability.[7] All Intel Ethernet products are backed by worldwide pre- and post-sales support and offer a limited lifetime warranty.

Verified Performance through Benchmark Testing

All Intel Select Solutions are verified through benchmark testing to meet a specified, minimum level of workload-optimized performance. In the case of Intel Select Solutions for Microsoft Azure Stack HCI, benchmark tests were conducted using DiskSpd*, a storage performance tool from Microsoft. The metrics and standards for Intel Select Solution verification are focused on the DiskSpd workload with the VMfleet* framework.[8]

The goal is to create a simple, repeatable test to evaluate the performance of the storage subsystem in Azure Stack HCI. Relevant metrics include I/O operations per second (IOPS) performance—the number of different I/O operations a device or group of devices can perform in one second—and latency measurements—the amount of time it takes for a single data request to be received and the right data found and accessed from the storage media. Both read and write latencies are measured because they can affect particular workloads differently.

Base and Plus Configurations

Intel Select Solutions for Microsoft Azure Stack HCI are available as two scalable reference designs—"Edge" and "Data Center"—with two configurations each, "Base" and "Plus," as shown in Appendix A.

The two-node Edge Base configuration and the four-node Data Center Base configuration specify the minimum required performance capability for Intel Select Solutions for Microsoft Azure Stack HCI. The configurations include Intel Xeon Gold processors with network, storage, and add-in platform-acceleration products optimized for mainstream pricing and performance.

The four-node Edge Plus configuration and the four-node Data Center Plus configuration provide examples of how system builders, system integrators, and solution and service providers can further optimize the solutions to achieve higher performance and capabilities. They call for high-performance Intel Xeon Gold processors and the best network, storage, and integrated platform-acceleration products optimized for high workload density and performance. For example, with the Plus configuration of Intel Select Solutions for Microsoft Azure Stack HCI Edge model, businesses can achieve four times greater memory capacity per cluster and five times greater raw storage capacity per cluster over the Base configuration.[9]

Intel® Select Solutions for Microsoft Azure Stack HCI*—Premium Model

OEMs and customers can build a premium, hyperconverged model that delivers the highest-performing software-defined storage available from Microsoft and Intel. Following a premium model, Storage Spaces Direct* in Windows Server 2019* and Intel® Optane™ DC persistent memory attained a hyperconverged infrastructure benchmark of more than 13.7M IOPS using 12 server nodes.[13]

The model includes:

- Intel® Xeon® Platinum processors
- Intel Optane DC persistent memory configured purely as storage over App Direct Mode
- Intel® Ethernet, which reduces processor overhead and increases performance of data centers powered by Intel® processors
- 8 TB, 64-layer, TLC Intel® SSD DC P4510 drives (based on Intel® 3D NAND technology and NVM Express* [NVMe*]), which double available capacity compared to their predecessor, the Intel SSD DC P4500

The Edge Plus, Data Center Base, and Data Center Plus configurations include Intel Optane DC persistent memory, which can improve performance and help increase the density of VMs running on Azure Stack HCI. Using persistent memory, the Edge Plus and Data Center Base configurations support Memory Mode, and the Data Center Plus configuration supports Dual Mode (Memory Mode and App Direct Mode).

The Plus configuration of the Edge model is identical to the Base configuration of the Data Center model, providing lower TCO using a shared platform and simplifying validation testing for Intel Select Solutions for Microsoft Azure Stack HCI.

With the Plus configuration of Intel Select Solutions for Microsoft Azure Stack HCI Edge model, businesses can add four times greater memory capacity per cluster and five times greater raw storage capacity per cluster over the Base configuration.[9]

With the Plus configuration of Intel Select Solutions for Microsoft Azure Stack HCI Data Center model, businesses can achieve 20 percent more cores for computation and 90 percent higher throughput in IOPS over the Base configuration.[10]

Technology Selections for Intel Select Solutions for Microsoft Azure Stack HCI

In addition to the Intel hardware foundation used for Intel Select Solutions for Microsoft Azure Stack HCI, other Intel technologies deliver yet more performance and reliability gains:

1. **Intel® Deep Learning Boost**, available on 2nd Generation Intel Xeon Scalable processors, takes embedded artificial-intelligence (AI) performance to the next level. Intel Xeon Scalable processors are built specifically for the flexibility to run complex AI workloads on the same hardware as your existing workloads. Some enterprises have experienced 57 percent performance improvement.[11]
2. **Intel® Advanced Vector Extensions 512 (Intel® AVX-512)** is a set of new CPU instructions that impacts compute, storage, and network functions. The number 512 refers to the width, in bits, of the register file, which sets the parameters for how much data a set of instructions can operate upon at a time. Intel AVX-512 enables twice the number of floating point operations per second (FLOPS) per clock cycle compared to its predecessor, Intel AVX2.[12]
3. **Intel® Run Sure Technology** delivers advanced reliability, availability, and serviceability (RAS), adding more resilience to Intel Xeon Scalable processors and helping to ensure the highest levels of uptime for your mission-critical workloads.[1]
4. **Intel® Platform Trust Technology (Intel® PTT)** offers the capabilities of discrete TPM 2.0. Intel PTT is a platform functionality for credential storage and key management. Intel PTT supports BitLocker* for hard-drive encryption and supports all Microsoft requirements for firmware Trusted Platform Module (TPM) 2.0.[1]
5. **Intel® Trusted Execution Technology (Intel® TXT) with One-Touch Activation** is a powerful component of enterprise data protection.[1] Intel TXT creates a hardware root of trust and a measured launch environment (MLE), which helps ensure that your server is running "known-good" configurations of your critical software components (firmware, BIOS, operating system, and hypervisors).

Bring Hyperconverged Infrastructure to the Data Center and the Edge with Intel Select Solutions for Microsoft Azure Stack HCI

Intel Select Solutions for Microsoft Azure Stack HCI are designed to deliver optimum performance for hyperconverged infrastructure built with Windows Server 2019, both in the data center and at the edge. The combination of Intel Xeon Gold processors, Intel Optane DC persistent memory, Intel Optane DC technology, Intel 3D NAND technology-based SSDs, and Storage Spaces Direct in Windows Server is a high-performing, risk-mitigated, cost-efficient solution for your IT environment. OEMs and IT organizations can scale up on any of the ingredients—processor SKUs, amount of memory, size of drives, and speed of networking—beyond the minimum prescribed in the Select Solutions.

Proven to scale with 2nd Generation Intel Xeon Scalable processors, these pre-tuned and tested configurations are workload-optimized and let organizations deploy data center infrastructure quickly and efficiently with less tuning.

Visit intel.com/selectsolutions to learn more, and ask your infrastructure vendor for Intel Select Solutions.

Learn More

Intel Select Solutions: **intel.com/selectsolutions**

Intel Xeon Scalable processors: **intel.com/xeonscalable**

Intel SSD Data Center Family: **intel.com/content/www/us/en/products/memory-storage/solid-state-drives/data-center-ssds.html**

Intel Optane DC SSDs: **intel.com/content/www/us/en/products/memory-storage/solid-state-drives/data-center-ssds/optane-dc-ssd-series.html**

Intel Optane DC persistent memory: **intel.com/optanememory**

Intel Ethernet Connection X722 Series: **intel.com/ethernet**

Intel Select Solutions are supported by Intel® Builders: **http://builders.intel.com**. Follow us on Twitter: **#IntelBuilders**

Storage Spaces Direct: **https://docs.microsoft.com/en-us/windows-server/storage/storage-spaces/storage-spaces-direct-overview**

Windows Admin Center: **https://aka.ms/WindowsAdminCenter**

Intel and Microsoft alliance: **intel.com/content/www/us/en/big-data/intel-microsoft-partnership.html**

Appendix A: The Base and Plus Configurations for Version 2 of the Intel Select Solutions for Microsoft Azure Stack HCI

To refer to a solution as an Intel Select Solution, a server vendor or data center solution provider must meet or exceed the defined minimum configuration ingredients and reference the minimum benchmark-performance thresholds listed below.

INGREDIENT	INTEL® SELECT SOLUTIONS FOR MICROSOFT AZURE STACK* HCI **EDGE MODEL, BASE CONFIGURATION** 1-TIER STORAGE CONFIGURATION CAPACITY/THROUGHPUT OPTIMIZED 2-NODE MINIMUM	INTEL SELECT SOLUTIONS FOR MICROSOFT AZURE STACK HCI **EDGE MODEL, PLUS CONFIGURATION** 2-TIER HARDWARE CONFIGURATION CAPACITY/THROUGHPUT OPTIMIZED 4-NODE MINIMUM
TOP OF RACK (TOR)	2-node crossover 10 gigabit Ethernet (GbE)	10 GbE/25 GbE SFP+ switch with redundancy
MANAGEMENT	1 GbE switch	1 GbE switch
PLATFORM	Intel® Server Board S2600WFT Qual	Intel Server Board S2600WFT Qual
PROCESSOR	2 x Intel® Xeon® Gold 5218 processor at 2.30 GHz (16 cores, 32 threads), or a higher number Intel Xeon Scalable processor	2 x Intel Xeon Gold 6230 processor at 2.10 GHz (20 cores, 40 threads), or a higher number Intel Xeon Scalable processor
MEMORY	256 GB (16 x 16 GB 2,666MHz 288-pin DDR4 RDIMM)	192 GB (12 x 16 GB 2,666 MHz 288-pin DDR4 DIMM)
PERSISTENT MEMORY	Not applicable (N/A)	512 GB Intel® Optane™ DC persistent memory (4 x 128 GB, 288-pin Intel Optane DC persistent memory Modules) in Memory Mode
PMEM-TO-DRAM RATIO	N/A	2.66:1 ratio persistent memory to DRAM
BOOT DRIVE**	1 x Intel® SSD DC S4510 (480 GB, 2.5-in. Serial ATA [SATA], 6 Gb/s, 20 nm, MLC)	1 x Intel SSD DC S4510 (480 GB, 2.5-in. SATA, 6 Gb/s, 20 nm, MLC)
CACHE TIER (NUMA BALANCED)	N/A	2 x Intel Optane SSD DC P4800X (375 GB, 2.5-in. PCIe* x4)
CAPACITY TIER (NUMA BALANCED)	4 x Intel SSD DC P4610 (1.6 TB, 2.5-in. PCIe 3.1 x 4, 3D2, TLC)	4 x Intel SSD DC P4510 (4.0 TB, 2.5-in. PCIe 3.1 x 4, 3D2, TLC)
DATA NETWORK**	10Gb dual-port Intel® C620 Series Chipset with integrated Intel® Ethernet Network Connection X722 and Intel® Ethernet Connection OCP X527-DA2 or 25 GbE dual-port network adapter (iWARP)	10Gb dual port Intel C620 Series Chipset with integrated Intel Ethernet Network Connection X722 and Intel Ethernet Connection OCP X527-DA2 or 25 GbE dual-port network adapter (iWARP)
MANAGEMENT NETWORK	1 GbE switch	1 GbE switch
INTEL® RSTE DRIVERS FOR SATA	Yes	Yes
WINDOWS SERVER 2019 DATACENTER EDITION* (1809 RS5) LTSC	32 cores per node—Microsoft license cost	40 cores per node—Microsoft license cost

APPLIES TO ALL NODES		
FIRMWARE AND SOFTWARE OPTIMIZATIONS	Intel® Volume Management Device (Intel® VMD) enabled Intel® Turbo Boost Technology enabled Intel® Hyper-Threading Technology (Intel® HT Technology) enabled Intel® Advanced Vector Extensions 512 (Intel® AVX-512) enabled[12] Intel® Speed Shift Technology enabled Intel® Boot Guard (security) enabled iWARP RDMA TPM 2.0 discrete or firmware TPM (Intel® Platform Trust Technology [Intel® PTT]) enabled Intel® Deep Learning Boost enabled Intel® Trusted Execution Technology (Intel® TXT) with One-Touch Activation enabled	Intel VMD enabled Intel Turbo Boost Technology enabled Intel HT Technology enabled Intel AVX-512 enabled[12] Intel Speed Shift Technology enabled Intel Boot Guard (security) enabled iWARP RDMA TPM 2.0 discrete or firmware TPM (Intel PTT) enabled Intel Deep Learning Boost enabled Intel TXT with One-Touch Activation enabled
MINIMUM PERFORMANCE STANDARDS Verified to meet or exceed the following minimum performance capabilities:[9]		
	270,000 IOPS; 4.4 ms read; 14.2 ms write latencies; queue depth = 8; write ratio = 30 198,000 IOPS; 1.84 ms read; 2.1 ms write latencies; queue depth = 1; write ratio = 30	520,000 IOPS; 5.6 ms read; 21.8 ms write latencies; queue depth = 8; write ratio = 30 420,000 IOPS; 1.1 ms read; 3.0 ms write latencies; queue depth = 1; write ratio = 30
BUSINESS VALUE OF CHOOSING A PLUS CONFIGURATION OVER A BASE CONFIGURATION With the Plus configuration of Intel Select Solutions for Microsoft Azure Stack HCI Edge model, businesses can achieve four times greater memory capacity per cluster and five times greater raw storage capacity per cluster over the Base configuration.[9]		

**Recommended, not required

INGREDIENT	INTEL® SELECT SOLUTIONS FOR MICROSOFT AZURE STACK* HCI **DATA CENTER MODEL, BASE CONFIGURATION** 2-TIER HARDWARE CONFIGURATION CAPACITY/THROUGHPUT OPTIMIZED 4-NODE MINIMUM	INTEL SELECT SOLUTIONS FOR MICROSOFT AZURE STACK HCI **DATA CENTER MODEL, PLUS CONFIGURATION** INTEL® OPTANE™ DC PERSISTENT MEMORY: 66% STORAGE AND 33% MEMORY 4-NODE MINIMUM
TOR	10 GbE/25 GbE SFP+ switch with redundancy	25 GbE/50 GbE SFP+ switch with redundancy
MANAGEMENT	1 GbE switch	1 GbE switch
PLATFORM	Intel® Server Board S2600WFT Qual	Intel Server Board S2600WFT Qual
PROCESSOR	2 x Intel® Xeon® Gold 6230 processor at 2.10 GHz (20 cores, 40 threads), or a higher number Intel Xeon Scalable processor	2 x Intel Xeon Gold 6252 processor at 2.10 GHz (24 cores, 48 threads), or a higher number Intel Xeon Scalable processor
MEMORY	192 GB (12 x 16 GB, 2,666 MHz, 288-pin DDR4 DIMM)	192 GB (12 x 16 GB, 2666 MHz, 288-pin DDR4 DIMM)
INTEL OPTANE DC PERSISTENT MEMORY	512 GB (4 x 128 GB, 288-pin Intel Optane DC persistent memory modules) in Memory Mode	1,536 GB Dual Mode (512 GB Intel Optane DC persistent memory in Memory Mode + 1,024 GB Storage over App Direct Mode [SToAD]) (12 x 128 GB, 288-pin Intel Optane DC persistent memory modules)
PMEM-TO-DRAM RATIO	2.66:1 ratio Intel Optane DC persistent memory to DRAM	2.66:1 ratio Intel Optane DC persistent memory to DRAM
BOOT DRIVE**	1 x Intel® SSD DC S4510 (480 GB, 2.5-in. SATA, 6 Gb/s, 20 nm, MLC)	2 x Intel SSD DC S4510 (480 GB, 2.5-in. SATA, 6 Gb/s, 20 nm, MLC)

CACHE TIER (NUMA BALANCED)	2 x Intel Optane SSD DC P4800X (375 GB, 2.5-in. PCIe* x4)	1,024 GB Intel Optane DC persistent memory in SToAD
CAPACITY TIER (NUMA BALANCED)	4 x Intel SSD DC P4510 (4.0 TB, 2.5-in. PCIe 3.1 x 4, 3D2, TLC)	4 x Intel SSD DC P4510 (4.0 TB, 2.5-in. PCIe 3.1 x 4, 3D2, TLC)
DATA NETWORK**	10Gb dual-port Intel® C620 Series Chipset with integrated Intel® Ethernet Network Connection X722 and Intel® Ethernet Connection OCP X527-DA2 or 25 GbE dual port network adapter (iWARP)	25 GbE dual-port network adapter (iWARP)
MANAGEMENT NETWORK	1 GbE switch	1 GbE switch
INTEL® RSTE DRIVERS FOR SATA	Yes	No
WINDOWS SERVER 2019 DATACENTER* EDITION (1809 RS5) LTSC	40 cores per node—Microsoft license cost	48 cores per node—Microsoft license cost
APPLIES TO ALL NODES		
FIRMWARE AND SOFTWARE OPTIMIZATIONS	Intel® Volume Management Device (Intel® VMD) enabled Intel® Turbo Boost Technology enabled Intel® Hyper-Threading Technology (Intel® HT Technology) enabled Intel® Advanced Vector Extensions 512 (Intel® AVX-512) enabled[12] Intel® Speed Shift Technology enabled Intel® Boot Guard (security) enabled iWARP RDMA TPM 2.0 discrete or firmware TPM (Intel® Platform Trust Technology [Intel® PTT]) enabled Intel® Deep Learning Boost enabled Intel® Trusted Execution Technology (Intel® TXT) with One-Touch Activation enabled	Intel VMD enabled Intel Turbo Boost Technology enabled Intel HT Technology enabled Intel AVX-512 enabled[12] Intel Speed Shift Technology enabled Intel Boot Guard (security) enabled iWARP RDMA TPM 2.0 discrete or firmware TPM (Intel PTT) enabled Intel Deep Learning Boost enabled Intel TXT with One-Touch Activation enabled
MINIMUM PERFORMANCE STANDARDS Verified to meet or exceed the following minimum performance capabilities:[10]		
	520,000 IOPS; 5.6 ms read; 21.8 ms write latencies; queue depth = 8; write ratio = 30 420,000 IOPS; 1.1 ms read; 3.0 ms write latencies ; queue depth = 1; write ratio=30	980,000 IOPS; 3.5 ms read; 6.2 ms write latencies; queue depth = 8; write ratio = 30 450,000 IOPS; 2.8 ms read; 3.1 ms write latencies; queue depth=1; write ratio=30

BUSINESS VALUE OF CHOOSING A PLUS CONFIGURATION OVER A BASE CONFIGURATION

With the Plus configuration of Intel Select Solutions for Microsoft Azure Stack HCI Data Center model, businesses can achieve 20 percent more cores for computation and 90 percent higher throughput in IOPS over the Base configuration.[10]

**Recommended, not required

[1] No product or component can be absolutely secure.

[2] See Plus configuration in Appendix A for details.

[3] In internal tests on a four-node cluster, a baseline configuration with 384 GB of DDR4 DRAM accommodated 41 VMs per node (164 VMs total). Intel® Optane™ DC persistent memory modules (in Memory Mode) accommodated 56 VMs per node (224 total), resulting in a 31 percent improvement in TCO with 36.6 percent increase in VM capacity using Intel Optane DC persistent memory at only +3 percent cost premium.

[4] Minimal 2 percent performance impact, considered negligible in virtualized machine scale.

[5] Testing based on the 2nd Generation Intel® Xeon® Platinum 8260 processor and upgrading from a 1GbE to a 10GbE Intel® Ethernet Network Adapter XXV710.

[6] Performance results by HeadGear Strategic Communications are based on testing as of February 12, 2019. The comparative analysis in this document was done by HeadGear Strategic Communications and commissioned by Intel. Detailed configuration details: **VM Host Server:** Intel® Xeon® Platinum 8160 processor, Intel Xeon Platinum 8160F processor (CPUID 50654, microcode revision 0x200004D), and Intel Xeon Platinum 8260 processor (CPUID 50656, microcode revision 04000014); Intel® Server Board S2600WFT (board model number H48104-850, BIOS ID SE5C620.86B.0D.01.0299.122420180146, baseboard management controller [BMC] version 1.88.7a4eac9e; Intel® Management Engine [Intel® ME] version 04.01.03.239; SDR package revision 1.88); 576 GB DDR4 2,133 MHz registered memory, 1 x Intel® Ethernet Network Adapter XXV710-DA2, 1 x Intel® Ethernet Converged Network Adapter X710-DA2; operating system drive configuration: 2 x Intel® SSD DC S3500 in Intel® Rapid Storage Technology enterprise [Intel® RSTe] RAID1 configuration. Windows Server 2016* Datacenter edition 10.0.14393 build 14393, Hyper-V* version 10.0.14393.0, Hyper-V scheduler type 0x3, installed updates KB4457131, KB4091664, KB1322316, KB3211320, and KB3192137. **E-mail Virtual-Machine Configuration:** Windows Server 2012 Datacenter edition 6.2.9200 build 9200; 4 x vCPU; 12 GB system memory, BIOS version/date: Hyper-V release v1.0, 2012, 11/26), SMBIOS version 2.4; Microsoft Exchange Server 2013*, workload generation via VM clients running Microsoft Exchange Load Generator 2013*, application version 15.00.0805.000). Database Virtual-Machine Configuration: Windows Server 2016 Datacenter edition 10.0.14393 build 14393, 2 x vCPU 7.5 GB system memory; BIOS version/date: Hyper-V release v1.0, 2012, 11/26), SMBIOS version 2.4, Microsoft SQL Server 2016* workload generation DVD Store application* (**dell.com/downloads/global/power/ps3q05-20050217-Jaffe-OE.pdf**). **Storage Server:** Intel® Server System R2224WFTZS; Intel Server Board S2600WFT (board model number H48104-850, BIOS ID SE5C620.86B.00.01.0014.070920180847, BMC version 1.60.56383bef; Intel ME version 04.00.04.340; SDR package revision 1.60); 96 GB DDR4 2,666 MHz registered memory, 1 x Intel Ethernet Network Adapter XXV710-DA2, 1 x Intel Ethernet Converged Network Adapter X710-DA2; operating system drive configuration: 2 x Intel SSD DC S3500 in Intel RSTe RAID1 configuration. **Storage Configuration:** 8 x Intel SSD DC P4600 (2.0 TB) configured as RAID 5 volume using Intel® Virtual RAID on CPU (Intel® VROC), 8 x Intel SSD DC S4500 (480 GB) in RAID5 configuration using Intel® RAID Module RMSP3AD160F, 8 x Intel SSD DC P4510 in RAID 5 configuration using Intel VROC for VM operating system store, Windows Server 2016 Datacenter edition 10.0.14393 build 14393, Hyper-V version 10.0.14393.0, Hyper-V scheduler type 0x3, installed updates KB4457131, KB4091664, KB1322316, KB3211320, and KB3192137. **Windows Server 2016 Datacenter and Windows Server 2012 Datacenter Configured with Intel Xeon Platinum 8160 and Intel Xeon Platinum 8160F Processors:** Speculation control settings for CVE-2017-5715 (branch target injection)—hardware support for branch target injection mitigation is present: true; Windows* operating system support for branch target injection mitigation is present: true; Windows operating system support for branch target injection mitigation is enabled: true; Windows operating system support for branch target injection mitigation is disabled by system policy: false; Windows operating system support for branch target injection mitigation is disabled by absence of hardware support: false. Speculation control settings for CVE-2017-5754 (rogue data cache load)—hardware requires kernel VA shadowing: true; Windows operating system support for kernel VA shadow is present: true; Windows operating system support for kernel VA shadow is enabled: true. Speculation control settings for CVE-2018-3639 (speculative store bypass)—hardware is vulnerable to speculative store bypass: true; hardware support for speculative store bypass disable is present: true; Windows operating system support for speculative store bypass disable is present: true; Windows operating system support for speculative store bypass disable is enabled system-wide: true. Speculation control settings for CVE-2018-3620 (L1 terminal fault)—hardware is vulnerable to L1 terminal fault: true; Windows operating system support for L1 terminal fault mitigation is present: true, Windows operating system support for L1 terminal fault mitigation is enabled: true. **Windows Server 2016 Datacenter and Windows Server 2012 Datacenter Configured with Intel Xeon Platinum 8160 and Intel Xeon 8160F Processors:** Speculation control settings for CVE-2017-5715 (branch target injection)—hardware support for branch target injection mitigation is present: true; Windows operating system support for branch target injection mitigation is present: true; Windows operating system support for branch target injection mitigation is enabled: true. Speculation control settings for CVE-2017-5754 (rogue data cache load)—hardware requires kernel VA shadowing: false. Speculation control settings for CVE-2018-3639 (speculative store bypass)—hardware is vulnerable to speculative store bypass: true; hardware support for speculative store bypass disable is present: true; Windows operating system support for speculative store bypass disable is present: true; Windows operating system support for speculative store bypass disable is enabled system-wide: true. Speculation control settings for CVE-2018-3620 (L1 terminal fault)—hardware is vulnerable to L1 terminal fault: false. **Network Switches:** 1/10GbE SuperMicro SSE-X3348S*, hardware version P4-01, firmware version 1.0.7.15; 10/25GbE Arista DCS-7160-48YC6*, EOS 4.18.2-REV2-FX.

[7] The Intel® Ethernet 700 Series includes extensively tested network adapters, accessories (optics and cables), hardware, and software, in addition to broad operating system support. A full list of the product portfolio's solutions is available at intel.com/ethernet. Hardware and software is thoroughly validated across Intel® Xeon® Scalable processors and the networking ecosystem. The products are optimized for Intel® architecture and a broad operating system ecosystem: Windows*, Linux* kernel, FreeBSD*, Red Hat* Enterprise Linux (RHEL*), SUSE*, Ubuntu*, Oracle Solaris*, and VMware ESXi*. Supported connections and media types for the Intel Ethernet 700 Series are: direct-attach copper and fiber SR/LR (QSFP+, SFP+, SFP28, XLPPI/CR4, 25G-CA/25G-SR/25G-LR), twisted-pair copper (1000BASE-T/10GBASE-T), backplane (XLAUI/XAUI/SFI/KR/KR4/KX/SGMII). Note that Intel is the only vendor offering the QSFP+ media type. The Intel Ethernet 700 Series supported speeds include 10GbE, 25GbE, 40GbE.

[8] VMfleet* testing was performed using 18 VMs per node, running Windows Server Core 2019*. Each VM had 4 cores with 8 GB of memory on a 40 GB virtual hard disk (VHDX) with a 10 GB test file. Test setup: 4 threads; 4 KB buffer size; random pattern; 300 seconds duration; queue depth of 8 and 1; write ratio of 0 and 30; 90 percent latency.

[9] Intel internal testing as of February 15, 2019. Intel® Select Solutions for Microsoft Azure Stack* HCI Edge model Base configuration: 2 x Intel® Xeon® Gold 5218 processor, Intel® Server Board S2600WFT, 256 GB total memory (8 x 32 GB, 2,666 megatransfers per second [MT/s]), Intel® Hyper-Threading Technology (Intel® HT Technology) enabled, Intel® Turbo Boost Technology enabled, storage (boot): 1 x 480 GB Intel® SSD DC 3520 U.2 SATA, storage tier: 4 x 1.6 TB Intel SSD DC P4610 PCIe* NVM Express* (NVMe*), 1 x 25 gigabits per second (Gbps) Chelsio* network adapter, 10 GbE, Windows Server 2019 Datacenter edition* build 17763. **Plus configuration:** 2 x Intel Xeon Gold 6230 processor, Intel Server Board S2600WFT, 512 GB Intel® Optane™ DC persistent memory (4 x 128 GB, 2,666 MT/s), 192 GB DRAM (12 x 16 GB, 2,666 MT/s), Intel HT Technology enabled, Intel Turbo Boost Technology enabled, storage (boot): 1 x 480 GB Intel SSD DC 3520 M.2 SATA, storage (cache): 2 x 375 GB Intel Optane SSD DC P4800X, storage (capacity): 4 x 4 TB Intel SSD DC P4510 PCIe NVMe, 1 x 25 gigabits per second (Gbps) Chelsio network adapter, 25 GbE, Windows Server 2019 Datacenter edition build 17763.

[10] Intel internal testing as of February 15, 2019. **Intel® Select Solutions for Microsoft Azure Stack* HCI Data Center model Base configuration:** 2 x Intel® Xeon® Gold 6230 processor, Intel® Server Board S2600WFT, 512 GB Intel® Optane™ DC persistent memory (4 x 128 GB, 2,666 megatransfers per second [MT/s]), 192 GB DRAM (12 x 16 GB, 2,666 MT/s), Intel® Hyper-Threading Technology (Intel® HT Technology) enabled, Intel® Turbo Boost Technology enabled, storage (boot): 1 x 480 GB Intel® SSD DC 3520 M.2 SATA, storage (cache): 2 x 375 GB Intel Optane SSD DC P4800X, storage (capacity): 4 x 4 TB Intel SSD DC P4510 PCIe* NVM Express* (NVMe*), 1 x 25 gigabits per second (Gbps) Chelsio* network adapter, 25 GbE, Windows Server 2019 Datacenter edition* build 17763. **Plus configuration:** 2 x Intel Xeon Gold 6252 processor, Intel Server Board S2600WFT, 1,584 GB Intel Optane DC persistent memory (12 x 128 GB, 2,666 MT/s), 192 GB DRAM (12 x 16 GB, 2,666 MT/s), Intel HT Technology enabled, Intel Turbo Boost Technology enabled, storage (boot): 1 x 480 GB Intel SSD DC 3520 M.2 SATA, storage (cache): 2 x 500 GB Intel Optane SSD DC persistent memory, storage (capacity): 4 x 4 TB Intel SSD DC P4510 PCIe NVMe, 1 x 25 gigabits per second (Gbps) Chelsio network adapter, 25 GbE, Windows Server 2019 Datacenter edition build 17763.

[11] To learn more about Intel® Deep Learning Boost, visit **intel.ai/intel-deep-learning-boost/**. For details on performance improvements from Intel Deep Learning Boost, visit **intel.ai/mlperf-results-validate-cpus-for-dl-training/#gs.a7dgBtry**.

[12] To learn more about Intel® Advanced Vector Extensions 512 (Intel® AVX-512), visit **intel.com/content/www/us/en/architecture-and-technology/avx-512-animation.html**.

[13] Microsoft. "The new HCI industry record: 13.7 million IOPS with Windows Server 2019 and Intel® Optane™ DC persistent memory." October 2018. **https://blogs.technet.microsoft.com/filecab/2018/10/30/windows-server-2019-and-intel-optane-dc-persistent-memory/**.

Performance results are based on testing as of the date set forth in the configurations and may not reflect all publicly available security updates. See configuration disclosure for details. No product or component can be absolutely secure.

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark* and MobileMark*, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more complete information visit intel.com/benchmarks.

Cost reduction scenarios described are intended as examples of how a given Intel- based product, in the specified circumstances and configurations, may affect future costs and provide cost savings. Circumstances will vary. Intel does not guarantee any costs or cost reduction.

Intel does not control or audit third-party benchmark data or the web sites referenced in this document. You should visit the referenced web site and confirm whether referenced data are accurate.

Optimization Notice: Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice. Notice Revision #20110804

Intel, the Intel logo, Intel Optane, and Xeon are trademarks of Intel Corporation or its subsidiaries in the U.S. and/or other countries.

*Other names and brands may be claimed as the property of others.

© 2019 Intel Corporation.

Printed in USA 0519/TC/PRW/PDF Please Recycle 338878-001US