

Intel® Select Solutions for Nutanix Cloud Platform

Seamlessly converge on-premises, edge and hybrid/multicloud environments into a single cloud infrastructure with Nutanix software running on the 3rd Generation Intel® Xeon® Scalable platform

Contents

Solution Brief 2
 Configuration Summary 5
 Introduction 5
 Key Technologies 5
 Reference Design Key Learnings ... 7



Authors:

Christine McMonigal, Director of Hyperconverged Marketing, Cloud & Enterprise Marketing
Mateusz S. Nowak, Cloud Solutions Engineer, Cloud & Enterprise Solutions Group
Patryk Wolsza, Cloud Solutions Architect, Cloud & Enterprise Solutions Group

Intel Contributors:

Maciej Cichocki, Marcin Hoffmann, Smita Kamat, Ewelina Kamyszek, Piotr Kiedrowski, Michael Velasco

Nutanix Contributors:

Hiren Desai, Rob Mills, Sivaprasath Thevendhriya Santharam, Allan Waters

Executive Summary

Today’s enterprise IT departments face multiple challenges, including:

- Legacy IT infrastructure that cannot easily or economically scale to meet today’s data-intensive enterprise needs.
- Data silos that hinder discovering critical business insights.
- Inability to consistently develop, deliver and maintain apps across an increasingly complex IT environment that spans from private cloud to public cloud to the edge.

Nutanix delivers a comprehensive hybrid/multicloud platform that bridges the gap between traditional on-premises infrastructure and public cloud services. Nutanix uses HCI as a foundation and can help enterprises reduce IT complexity, make better use of their volumes of data and speed time to value. Enterprises can use easy-to-manage, high-performing HCI to focus on customer and business needs and run business-critical workloads such as data analytics, AI, ERP, collaboration, databases and VDI—all on a workload-optimized and cloud-ready infrastructure.

Intel® Select Solutions for Nutanix Cloud Platform provide a turnkey solution that can help enhance storage performance and application responsiveness as well as offer a faster, simpler path to infrastructure modernization and hybrid/multicloud environments. These solutions enable efficient use of infrastructure and deliver the necessary performance for demanding, latency-sensitive workloads in the data center. The solutions combine a Nutanix software stack with hardware built on 3rd Generation Intel® Xeon® Scalable processors, Intel® Optane™ technology, Intel® Ethernet Network Adapters, and other Intel technologies. Additionally, they are pre-configured and verified to help enterprises quickly modernize infrastructure to support multiple complex workloads simultaneously. Intel Select Solutions for Nutanix Cloud Platform help improve both capital expenditure and operating expense efficiency by offering high-performing, scalable HCI solutions; the ability to consolidate multiple workloads; and the flexibility to simplify deployment and management.

Intel® Select Solutions for Nutanix Cloud Platform

Intel Select Solutions power Nutanix Cloud Platform deployments with 3rd Gen Intel Xeon Scalable processors, Intel Optane persistent memory (PMem), Intel Optane SSDs, Intel Ethernet Network Adapters and other Intel technologies.

PERFORMANCE OPTIMIZED FOR NUTANIX SOFTWARE

REDUCE TIME TO EVALUATE, SELECT AND PURCHASE HARDWARE

MINIMIZE TIME TO DEPLOY NEW INFRASTRUCTURE

DELIVER PERFORMANCE OPTIMIZED TO A SPECIFIC THRESHOLD

Solution Brief

Business Challenge

Legacy IT infrastructure, with separate compute, storage and memory, and networking resources, cannot easily or economically scale to meet today's data-intensive enterprise needs. With legacy architecture, the data tends to become siloed, resulting in inefficient use of infrastructure, because some systems go under-utilized while others are over-utilized. In addition, critical insights may go undiscovered because the data can't be analyzed across disparate systems. Enterprises spend a lot of time maintaining infrastructure that cannot adapt to new demands, leaving little time to focus on strategic initiatives that can drive business benefits.

To solve some of these challenges, IT departments are increasingly turning to hybrid/multicloud infrastructure. In this scenario, some workloads run in the on-premises private cloud, while others run in one or more public clouds. This hybrid/multicloud environment brings its own set of challenges, such as maintaining consistent development, deployment, security and governance as well as management tools and processes.

Solution Value

Enterprises need to tap into their vast quantities of data to help make better decisions and increase competitiveness. An important part of digital transformation, hyperconverged infrastructure (HCI) is a popular strategy for infrastructure modernization on-premises, in the cloud and at the edge. HCI can help reduce overall IT complexity and costs and meet growing compute, storage and memory, and networking needs. Through a long-standing strategic collaboration, Nutanix and Intel offer the ability to run applications and services on a reliable platform that spans the core data center (on-premises), edge locations and multiple public clouds. This flexible platform is simple to deploy, manage and scale.

Intel® Select Solutions for Nutanix Cloud Platform help simplify the time and resources required for IT to evaluate, choose and deploy new infrastructure. Intel Select Solutions are a co-engineered and qualified software and hardware stack that also provides the flexibility to choose from various server manufacturers and hypervisors. By modernizing legacy infrastructure to a platform based on high-performance Intel technologies and Nutanix software, enterprises can cost-effectively scale to support increasingly demanding workloads. This can happen incrementally on-premises with one node at a time or in the public cloud by scaling instances. Nutanix software and Intel's broad portfolio of technologies can be tailored to a variety of private or hybrid/multicloud use cases and workloads, providing the right balance of compute, storage and memory, and network resources. A streamlined and consolidated virtualized infrastructure can provide enterprises with an easier path to hybrid/multicloud for current and future needs.

Solution Benefits

- High-performance hyperconverged infrastructure (HCI) can handle today's data-intensive workloads like virtualized desktop infrastructure (VDI), database transactions and data warehousing.
- Simplified cloud operations make app development, deployment and maintenance consistent across public clouds, private clouds and the edge.
- Scalable Intel® architecture-based solutions let enterprises add compute and storage resources as needed.
- Co-engineered and qualified HCI hardware/software and a unified management plane takes the guesswork out of moving to hybrid/multicloud.

Intel Select Solutions for Nutanix Cloud Platform showcase the benefits of using 3rd Generation Intel® Xeon® Scalable processors with Nutanix software. (See "[Key Technologies](#)" later in this document for more details on the components used in the Intel hardware and Nutanix software solution.) By deploying Intel Select Solutions for Nutanix Cloud Platform, customers can obtain the following benefits:

- **Easy manageability.** The solution uses Nutanix Cloud Clusters, which help integrate the primary on-premises private cloud Nutanix HCI cluster with bare-metal Nutanix instances on Amazon Web Services (AWS); they can also integrate any number of smaller edge Nutanix HCI clusters. Nutanix Cloud Clusters help make it possible to manage all of the infrastructure (on-premises, cloud or edge) from one dashboard—Nutanix Cloud Manager (NCM). With a single pane of glass, there is no need to train personnel to operate multiple systems.
- **Performant virtual desktop infrastructure (VDI).** To support virtual desktops anywhere in the world without throughput and latency issues, the solution uses Nutanix Frame (a desktop-as-a-service [DaaS] solution), that is managed from the central NCM portal. Desktop VMs can be spawned anywhere, including in public clouds like AWS, Google Cloud Platform (GCP) and Microsoft Azure; in an on-premises Nutanix HCI cluster; in a smaller edge Nutanix cluster; or on Nutanix bare-metal instances residing in the public cloud.
- **Ease of migration.** Integrating Nutanix Cloud Clusters and Frame enables VMs to migrate from one cluster to another, no matter where those clusters are located.
- **Hybrid cloud data warehousing.** Nutanix Database Service lets organizations consolidate and manage all of their database engines from a single user interface with one click. It supports many leading database engines like Oracle, Microsoft SQL Server, SAP HANA, MySQL, PostgreSQL and MariaDB. Nutanix Database Service enables true hybrid/multicloud database management that is capable of spawning databases from one simple control plane across public and private cloud deployments.

Solution Architecture Highlights

Intel Select Solutions for Nutanix Cloud Platform (see Figure 1) combine the latest hardware and software innovations from Intel and Nutanix to provide a high level of performance and scalability. For this Intel Select Solution, we tested multiple aspects of the Nutanix Cloud Platform. A cluster in our main data center lab environment ran multiple Microsoft SQL Server instances using Nutanix Database Service to manage the instances. We ran Nutanix Frame service to connect remote workers to an edge remote office location for VDI and for running database instances closer to the users. Finally, we used Nutanix Cloud Clusters to extend compute to additional nodes at AWS, where we created VMs. We migrated a VM from the main data center by opening a tunnel between the locations, with a data protection domain established between the clusters. Nutanix Prism enabled us to have visibility across sites and set policies for security and automating management.

We also benchmarked the core HCI capabilities while running I/O and SQL database workloads. Customers can choose between a Base and a Plus design, depending on workload requirements. The result is performance that is equal or better than many storage area network (SAN) configurations, with millions of IOPS and consistent sub-millisecond response times being delivered.¹

The solution is powered by 3rd Gen Intel Xeon Scalable processors, which have many performance enhancements compared to previous-generation processors. Nutanix and Intel architects and engineers collaborate to optimize Nutanix software to take advantage of 3rd Gen Intel Xeon Scalable processor features such as Intel® Volume Management Device (Intel® VMD) to improve serviceability of NVMe devices without sacrificing the high performance provided by Nutanix Blockstore with the Storage Performance Development Kit (SPDK), available via open source on GitHub.

What Are Intel® Select Solutions?

Intel® Select Solutions are predefined, workload-optimized solutions designed to minimize the challenges of infrastructure evaluation and deployment. These solutions are validated by OEM/ODMs, certified by ISVs and verified by Intel.

All Intel Select Solutions are a tailored combination of Intel data center compute, storage and memory, and network technologies that deliver predictable, trusted and compelling performance. Each solution is rigorously benchmarked, offering assurance that the workload will perform as expected, if not better, which can save individual businesses from investing the resources that might otherwise be used to evaluate, select and purchase the hardware components to gain that assurance themselves.

The Plus design features Intel® Optane™ persistent memory (PMem), a unique media type that offers DRAM-like latency and bandwidth with capacity comparable to storage media. Intel Optane PMem cost-efficiently boosts memory capacity to support memory-hungry workloads like data warehousing or to support more VDI users from the same cluster.

In addition to powerful compute resources, the Plus design uses Intel® Optane™ SSDs for metadata and to accelerate reads from storage. Intel Optane SSDs deliver an industry-leading combination of low latency, outstanding quality of service (QoS) and high endurance, which accelerates storage workloads. NVMe NAND SSDs are used for capacity storage in the Plus configuration. Starting from version 6.1, Nutanix AOS provides Advanced NVMe Tiering for Optane, which is automatically used for frequently read random data as well as logs.

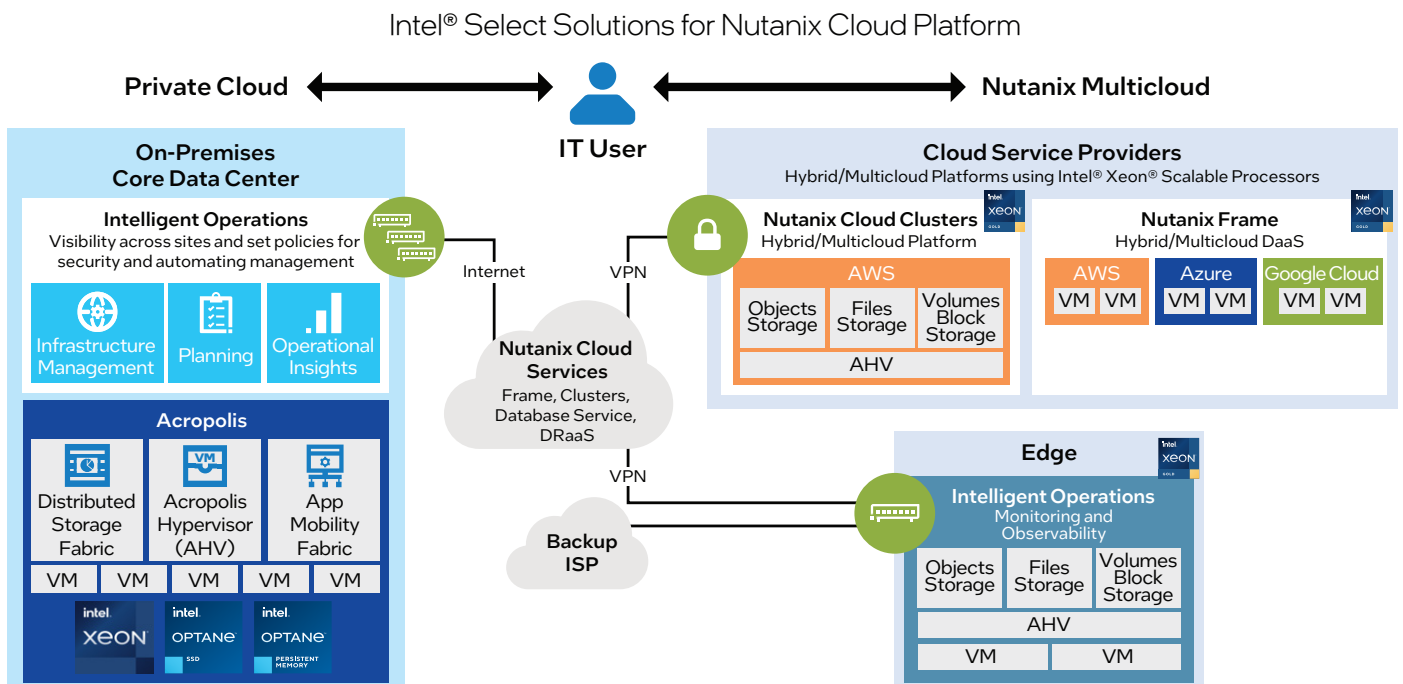


Figure 1. Intel® Select Solutions for Nutanix Cloud Platform provide the modern hybrid/multicloud infrastructure that today's enterprises need.

Software and Hardware Architecture Considerations

To understand the difference between the Base and Plus designs, refer to Figure 2, which shows the I/O path for operations to the storage layer. Nutanix software identifies hardware that the system uses and adjusts write and read operations to use the benefits of different technologies. For this Intel Select Solution, both the Base and Plus designs use all-flash storage configurations. However, the Base design is a combination of SATA SSDs and NVMe SSDs, whereas the Plus design is all-NVMe that uses the Intel Optane SSD P5800X as well as Intel Optane PMem 200 series.

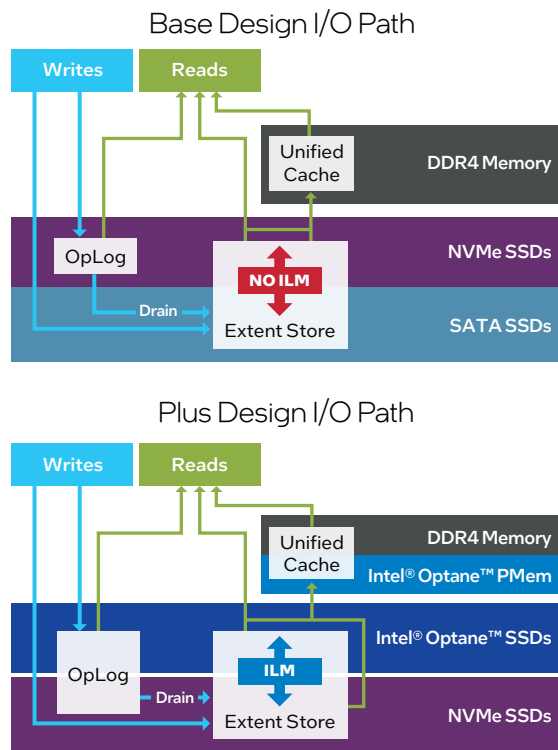


Figure 2. Base and Plus designs have slightly different architectures. The blue and green lines are the I/O paths for operations to the storage layer.

From a software perspective, there are two main differences between the Base and Plus designs. In the Base design, only the Operations Log (OpLog) is written to the NVMe devices and no Information Lifecycle Management (ILM) is used to migrate data.

In the Plus design, writes go to the OpLog, which is stored in both the NVMe and Intel Optane SSD tiers, and in the background the ILM process migrates the cold and hot data between tiers. In addition, Unified Cache for read operations can take advantage of a larger amount of memory by using Intel Optane PMem, without significant performance impact.

From an end-user perspective, both designs can perform well, but using Intel Optane technologies with 3rd Gen Intel Xeon Scalable processors enables extra features that improve not only performance but significantly reduce latency for workloads hosted on the Nutanix HCI clusters.

Overall, the solution delivers turnkey infrastructure (with configurations available from multiple server vendors) that integrates compute, storage and memory, and networking resources; supports virtualization; and provides end-to-end management capabilities.

Results

In benchmarking tests² running X-Ray, Intel Select Solutions for Nutanix Cloud Platform Base design achieved up to 1,033,209 IOPS (random read, X-Ray test). HammerDB testing on seven instances of Microsoft SQL Server resulted in 2,976,625 new orders per minute (NOPM). This compared with 1,559,207 NOPM on the previous-generation platform, an improvement of 91%. Average I/O latency measured on the Nutanix storage cluster controller during the test on the seven instances of SQL improved from 5.3 to 4.1 ms gen-over-gen, an average of 29%. These results demonstrate that Intel Select Solutions for Nutanix Cloud Platform running on the latest Intel Xeon Scalable processors can support a heavy online transaction processing (OLTP) workload and simultaneously have compute, storage and memory, and networking resources available to support other workloads running on the cluster.

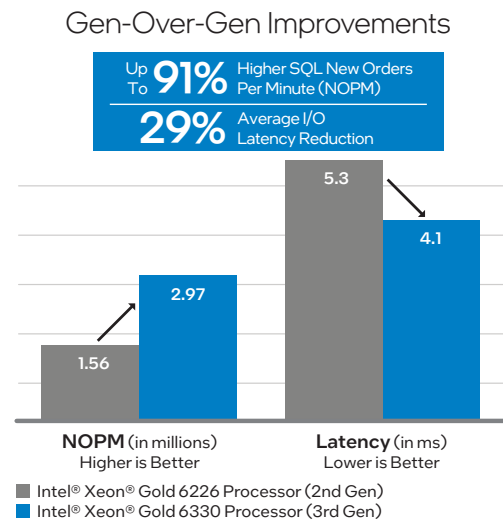


Figure 3. Intel® Select Solutions for Nutanix Cloud Platform can provide better performance and lower latency than on a previous-generation platform.

Learn More

- [Intel Select Solutions](#)
- [Nutanix Cloud Platform](#)
- [Nutanix Supports Intel Optane Persistent Memory for VDI Workloads](#) solution brief
- [Nutanix Bible](#) for in-depth technical information about the Nutanix platform architecture
- [3rd Gen Intel Xeon Scalable processors](#)
- [Intel Optane PMem](#)
- [Intel Optane SSDs](#)
- [Intel Ethernet Adapters](#)

Find the solution that is right for your organization. Contact your Intel representative.

Configuration Summary

Introduction

The previous pages provided a high-level discussion of the business value of Intel Select Solutions for Nutanix Cloud Platform and the technologies used in the solution. This section provides more detail about those technologies and the bill of materials for the Base and Plus designs.

Key Technologies

This section contains information about the components that make up Intel Select Solutions for Nutanix Cloud Platform.

Hardware Innovations from Intel

3rd Generation Intel Xeon Scalable Processors

Intel's latest processors for data center workloads are [3rd Gen Intel Xeon Scalable processors](#). They are packed with performance- and security-enhancing features, including the following:

- Enhanced per-core performance, with up to 40 cores in a standard socket.
- Enhanced memory performance with support for up to 3200 MT/s DIMMs (2 DIMMs per channel) and increased memory capacity with up to eight channels.
- Support for [Intel Optane PMem 200 series](#).
- Increased I/O bandwidth, along with PCI Express 4 and up to 64 lanes (per socket) at 16 GT/s.

Intel Optane PMem

[Intel Optane PMem](#) is a unique memory media that fills the performance gap between volatile memory (DRAM, with nanosecond-level response time) and lower-performing storage (microsecond-level response time at best).³

Buying more DRAM to handle today's data-intensive workloads can be prohibitively expensive. Intel Optane PMem is less expensive than DRAM and is available in far larger capacities. Displacing the majority of DRAM in a VDI system with Intel Optane PMem, for example, can drive down the cost per VDI session by up to 30% while delivering comparable performance to VDI users.⁴

Intel Optane PMem 200 series is the second generation of Intel Optane PMem, and is available in 128 GB, 256 GB and 512 GB modules. Intel Optane PMem modules coexist with traditional DDR4 DIMMs, with up to 4 TB of memory per socket. The 200 series offers several enhancements compared to Intel Optane PMem 100 series:

- Increased maximum DDR-T speed from 2666 MT/s to 3200 MT/s (2 DIMMs per channel).
- An average of 32% higher memory bandwidth per channel.⁵
- Improved application performance by using extended asynchronous DRAM refresh (eADR) to avoid CPU cache flush commands at run time.

Intel Optane SSDs

[Intel Optane SSDs](#) help remove data bottlenecks to accelerate transactions and time to insights, so users get what they need, when they need it. Intel Optane SSDs deliver fast, predictable performance—even in the most demanding environments. With high QoS and at least 6x greater 4 KB block bandwidth with bi-directional read/write capability than NAND SSDs at low queue depths⁶, the Intel Optane SSD P5800X is the world's fastest SSD.⁷ Nutanix AOS 6.1 and later takes advantage of the high performance of Intel Optane drives by adding Advanced NVMe Tiering for Optane for frequently read data in all-NVMe configurations and for logs.

Intel® Ethernet Products

[Intel Ethernet products](#) are the foundation for server and appliance connectivity. They provide broad interoperability, critical performance optimizations, and increased agility for communications, cloud, and enterprise IT network solutions. Intel Ethernet adapters provide flexible and scalable I/O virtualization with intelligent offloads for improved performance and efficiency. Intel Ethernet Controllers, adapters, and accessories deliver speeds from 1 to 100 GbE—with versatile capabilities to optimize workload performance.

Intel Ethernet 700 Series accelerate the delivery of new services and capabilities through intelligent offloads, sophisticated packet processing, and quality open-source drivers. The [Intel® Ethernet Network Adapter XXV710](#) expands the Intel® Ethernet 700 Series product offering, providing a natural upgrade migration path for customers who need more bandwidth.

Intel® VMD

Intel VMD is an Intel Xeon Scalable processor feature that enables direct control and management of NVMe SSDs from the PCIe bus without additional hardware adapters. This robust NVMe SSD functionality allows a seamless transition to NVMe storage while limiting the downtime of critical infrastructure. Intel VMD brings enterprise RAS features to NVMe SSDs, enabling enterprises to deploy next-generation storage with confidence. Enterprises can use Intel VMD to get hot plug capabilities with LED management and broad ecosystem support.

SPDK

The SPDK provides a set of tools and libraries for writing high-performance, scalable user-mode storage applications. As of Nutanix AOS v5.19.1, SPDK is enabled by default on NVMe-based Nutanix solutions.

Nutanix Components

Intel Select Solutions for Nutanix Cloud Platform span from edge to core data center to cloud. The following sections provide a high level of detail about the various components of the Nutanix Cloud Platform.

Edge

Edge computing runs workloads near where the data is generated or processes occur. This can happen across a set of physical footprints that range from the thin edge of one or two servers or small-form factor servers to the thick edge where multiple servers are needed to handle bigger storage and compute demands. Close proximity to the data can greatly reduce response latency and provide faster insights and decisions. Read the [brief from Nutanix](#) for more details about the application of Nutanix technologies to edge computing (as well as remote office branch office computing).

Nutanix Frame

[Nutanix Frame](#) is a hybrid and multicloud DaaS platform that enables customers to use a browser to deliver Windows and Linux virtual apps and desktops to end-users. While Frame's control plane is hosted in the cloud-as-a-service (CaaS), customers have the option to deploy their Frame environment on one or more of the following platforms:

- **AWS.** The process of integrating an AWS Account to Frame is detailed [here](#).
- **Azure.** The process of integrating an Azure Subscription with Frame is detailed [here](#).
- **Google Cloud.** The process of integrating a Google Cloud Project with Frame is detailed [here](#).

- **Nutanix AHV.** The process of integrating Nutanix AHV Clusters with Frame is detailed [here](#).

Learn more about the latest developments in Nutanix Frame [here](#). To test drive Frame for free, click [here](#).

Nutanix Cloud Clusters

[Nutanix Cloud Clusters \(NC2\)](#) is a hybrid/multicloud platform with natively integrated networking between private and public clouds. It allows seamless application migration and license portability across all environments and enables customers to run the full Nutanix software stack anywhere—in private or public clouds.

Nutanix Database Service

[Nutanix Database Service](#) is the only hybrid/multicloud database-as-a-service (DBaaS) for Microsoft SQL Server, Oracle Database, PostgreSQL, MongoDB and MySQL. This service enables enterprises to efficiently manage hundreds to thousands of databases and to simplify development and operations without sacrificing control or flexibility.

Intel Select Solutions for Nutanix Cloud Platform Designs

The following tables describe the required components needed to build Base and Plus designs. Customers must use firmware with the latest microcode. The selection of software, compute, network and storage components is essential to achieving optimal performance.

Table 1. Hardware Bill of Materials for a Base and Plus Design (four-node cluster)

Hardware	Base Design (per Node)	Plus Design (per Node)	Required or Recommended
CPU	2x Intel® Xeon® Gold 6330 processor (28 cores, 2.0 GHz, 205 W TDP) or higher number SKU	2x Intel® Xeon® Gold 6348 processor (28 cores, 2.6 GHz, 235 W TDP) or higher number SKU	Required
Memory (DRAM)	512 GB (16x 32 GB 2933 MHz DDR4 RDIMM)	256 GB (16x 16 GB 3200 MHz DDR4 RDIMM)	Required
Intel® Optane™ PMem–Memory Mode	N/A	1024 GB Intel Optane PMem 200 Series (8x 128 GB 3200 MHz DDR4 LRDIMM)	Required for Plus Design
Boot Drive	1x SSD D3-S4510 240 GB M.2	1x SSD D3-S4510 240 GB M.2	Recommended
Metadata Drive	2x SSD P4510 2.0 TB PCIe	2x Intel® Optane™ SSD P5800X 800 GB 2.5" PCIe	Required
Capacity Drives	4x SSD S4510 1.92 TB 2.5" SATA	4x SSD D7-P5510 3.84 TB 2.5" PCIe	Recommended
Data Network Card	1x Intel® Ethernet Converged Network Adapter (XXV710-DA2 SFP)	2x Mellanox MCX516A-CCAT ConnectX-5 (RDMA enabled)	Recommended
Network Card	1x Integrated 1GbE	1x Integrated 1GbE	Required

Table 2. Software Requirements for Base and Plus Designs

Hardware	Base Design	Plus Design	Required or Recommended
Operating System	<ul style="list-style-type: none"> ▪ Nutanix AOS 5.20.1.1 LTS or later ▪ Nutanix Cluster Check 4.2.0.1 ▪ Life Cycle Manager 2.4.2.1 	<ul style="list-style-type: none"> ▪ Nutanix AOS 6.1 STS or later for Intel® Optane™ SSD tiering ▪ Nutanix Cluster Check 4.4.0 ▪ Life Cycle Manager 2.4.5 	Required
Hypervisor	Nutanix AHV 20201105.2096	Nutanix AHV 20201105.30142	Required
Benchmarking Tools	HammerDB 4.1, Windows Server 2019 (with latest CU), Microsoft SQL Server 2019 (with latest CU), ODBC Driver 17 for SQL Server, Nutanix X-Ray 4.0.2		Required

Table 3. Network Requirements

Hardware	Description	Qty	Required or Recommended
Top of the Rack Switch	25 GbE per port, switch capabilities: Jumbo Frames, DCB (Data Center Bridging) with PFC (Priority Flow Control)	1	Recommended
Management Switch	1GbE per port	1	Recommended

Table 4. Platform and Software Settings

BIOS/Firmware Option	Set To	Required or Recommended
Intel® Hyper-Threading Technology	Enabled	Required
Intel® Turbo Boost Technology	Enabled	Required
Prefetcher Section	All Enabled	Required
Enhanced Intel SpeedStep® Technology	Enabled	Required
CPU Power and Performance Policy	Performance	Required
Activate SST-BF	Disabled	Required
Package C State	C0/C1 State	Required
CIE	Disabled	Required
Processor C6	Disabled	Required
Trusted Platform Module (TPM) 2.0	Enabled	Required

Table 5. Firmware and Microcode Versions

Ingredient	Version	Required or Recommended
CPU Microcode	0xd000280	Required
Intel® Optane™ Persistent Memory 200 Series 128 GB	2.2.0.1553	Required
SSD D3-S4510 240 GB M.2 SATA	XC311132	Required
SSD P4510 2.0 TB PCIe	VDV10170	Required
SSD D3-S4510 1.92 TB 2.5" SATA	XCV10132	Required
Intel® Optane™ SSD P5800X 800 GB PCIe	L0310200	Required
SSD D7-P5510 3.84 TB 2.5" PCIe	JCV10100	Required
Intel® Ethernet Converged Network Adapter XXV710-DA2 SFP	8.21 (decimal)	Required
Mellanox MCX516A-CCAT ConnectX-5	16.31.1014	Required

Reference Design Key Learnings

The path of developing an Intel Select Solution from discovery to build is a complex process in which the team tested multiple hardware and software configurations and adjusted them to achieve the best result. Listed below are the most important key learnings to consider when building a solution with Nutanix software.

- Intel has a very broad portfolio of 3rd Gen Intel Xeon processors that have a wide range of parameters like core count and base frequency. The tests helped us to understand that Intel® Turbo Boost Technology and turbo frequency on all cores are even more important than base frequency. In our example, for the Base design we chose the Intel Xeon Gold 6330 processor with a 2.0 GHz clock frequency, while for the Plus design we used the Intel Xeon Gold 6348 processor with a 2.6 GHz clock frequency. That represents a 0.6 GHz difference. SQL workloads are CPU-intensive and benefit from a high-frequency clock. During a heavy load, we found that we can achieve maximum frequency on all cores in turbo mode (3.4 GHz) on the Intel Xeon Gold 6348 processor and 2.6 GHz on the Intel Xeon Gold 6330 processor, which represents a difference of 0.8 GHz. In summary, for CPU-intensive workloads, the ideal SKU should have a high base frequency but also stable high frequency under heavy load. The Intel Xeon Gold 6348 processor is a good example of such a SKU.
- To properly tune the environment, BIOS settings like CPU power and performance policy are important. To achieve the best results, we recommend setting the BIOS to the performance setting and then verify that the CPU is configured with C0/C1 C-states. These settings help produce the most powerful platform results.
- Design of the solution is a complex process; engineers must understand the low-level techniques that are used by hardware and software. In the "Software and Hardware Architecture Considerations" section above, we described how read and write operations are handled by the storage layer. From an end-user perspective, it is important to choose hardware that can best utilize everything the software offers. In our case, Intel Optane SSDs and Intel Optane PMem helped to create an environment for latency-sensitive workloads like SQL, while at the same time use software technologies from Nutanix AOS that are designed especially for that hardware.



¹ See <https://www.n0derunner.com/2021/11/24/nutanix-performance-for-database-workloads/> and <https://www.esg-global.com/validation/esg-technical-validation-analysis-of-enterprise-databases-and-applications-running-on-nutanix-cloud-platform>

² Testing by Intel as of January 2022 (SQL: Base 3rd Gen Intel® Xeon® Scalable processor and Base 2nd Gen Intel Xeon Scalable processor designs) and April 2022 (SQL: Plus 3rd Gen Intel Xeon Scalable processor design and X-Ray: Base 3rd Gen Intel Xeon Scalable processor and Plus 3rd Gen Intel Xeon Scalable processor). Results may vary. See Appendix A for details on the software used for testing.

Base 2nd Gen Intel Xeon Scalable processor configuration: 4-node configuration. Each node includes: 2x Intel® Xeon® Gold 6226 processor, 1x Intel® Server Board S2600WFO, Total Memory = 384 GB (12 slots/32 GB/2933 MHz), Intel® Hyper-Threading Technology = ON, Intel® Turbo Boost Technology = ON, BIOS: SE5C620.86B.02.01.0008, CNX01.031920191559 (ucode: 0x0500002c), Storage (boot): 1x D3-S4510 240 GB M.2, Storage (cache): 2x P4510 2 TB 2.5" PCIe, Storage (capacity): 4x S4510 1.92 TB 2.5" SATA, Network devices: 1x Intel® Ethernet Converged Network Adapter X710-DA2 SFP, Hypervisor: Nutanix AOS 5.20.1.1 LTS with AHV build 20201105.2096, OS/Software: Windows Server 2019 Datacenter (version 1809) build 17763.2029, 12 vCPU, 120 GB vRAM.

Base 3rd Gen Intel Xeon Scalable processor configuration: 4-node configuration. Each node includes: 2x Intel® Xeon® Gold 6330 processor, 1x Intel® Server Board M50CYP2UR, Total Memory = 512 GB (16 slots/32 GB/2933 MHz), Intel® Hyper-Threading Technology = ON, Intel® Turbo Boost Technology = ON, BIOS: SE5C620.86B.01.01.1003, CNX03.2106150155 (ucode: 0xd000280), Storage (boot): 1x D3-S4510 240 GB M.2, Storage (cache): 2x P4510 2 TB 2.5" PCIe, Storage (capacity): 4x S4510 1.92 TB 2.5" SATA, Network devices: 1x Intel® Ethernet Network Adapter XXV710 for 25 GbE SFP+, Hypervisor: Nutanix AOS 5.20.1.1 LTS with AHV build 20201105.2096, OS/Software: Windows Server 2019 Datacenter (version 1809) build 17763.2029, 28 vCPU, 170 GB vRAM.

Plus 3rd Gen Intel Xeon Scalable processor configuration: 4-node configuration. Each node includes: 2x Intel® Xeon® Gold 6348 processor, 1x Intel Server Board M50CYP2UR, Total Memory = 1024 GB (Memory Mode) - 256 GB DRAM cache (16 slots/16 GB/3200 MHz) + 1024 GB Intel® Optane™ persistent memory 200 series (8 slots/128 GB/3200 MHz), Intel Hyper-Threading Technology = ON, Intel Turbo Boost Technology = ON, BIOS: SE5C620.86B.01.01.1003, CNX03.2106150155 (ucode: 0xd000280), Storage (boot): 1x D3-S4510 240 GB M.2, Storage (cache): 2x Intel Optane SSD P5800X 800 GB 2.5" PCIe, Storage (capacity): 4x P5510 3.84 TB 2.5" PCIe, Network devices: 2x Mellanox MCX516A-CCAT ConnexX-5, Hypervisor: Nutanix AOS 6.1 STS with AHV build 20201105.30142, OS/Software: Windows Server 2019 Datacenter (version 1809) build 17763.2029, 28 vCPU, 170 GB vRAM.

³ Intel® Optane™ SSD response time = ~6 µs: Based on Intel testing of a 1.6 TB Intel® Optane™ SSD P5800X as of September 25, 2020: Intel® Xeon® Gold 6254 processor (3.10 GHz, 30 MB, 160 W, 18 cores per socket, 2 sockets), BIOS: SE5C620.86B.02.01.0009.092820190230, 32 GB RAM (DDR4), RAM stuffing: NA, DIMM slots populated: 4 slots, PCIe attach: CPU (not PCH lane attach), chipset: Intel® C610 Chipset, switch/ReTimer model/vendor: Intel® G4SAC switch (PCIe Gen4), OS: CentOS 7.5.1804, kernel: 4.14.74, FIO version: 3.5; NVMe driver: Inbox, C-states: Disabled, Intel® HT Technology disabled, CPU governor (through OS): performance mode. Enhanced Intel SpeedStep® Technology, Intel® Turbo Boost Technology, and P-states disabled; IRQ balancing services (OS) off; SMP affinity set in the OS; queue depth 1 (QD1) utilizes I/O polling mode with ioengine=pvsync2/hipri.

Intel® Optane™ persistent memory response time = ~100 to 340 ns (64B block): Intel Optane PMem 200 series tested by Intel on a single-DIMM configuration as of September 25, 2020. 3rd Generation Intel® Xeon® Scalable processor; chipset LBG B1; 26 cores, 1 socket; DDR speed: 2,666 MT/s; 256 GB Intel Optane PMem module, 15 W memory configuration, 1 channel, 32 GB DDR4 (six per socket); Intel Optane PMem firmware: 2.2.0.1516; BIOS 0017.P23; best-known configuration (BKC) version WW38 BKC, Linux OS Fedora release 29 4.20.6-200.fc29.x86_64; Spectre/Meltdown patched (1,2,3a,4); performance tuning quality of service disabled, IODC=5(AD). Intel Optane PMem uses DDRT memory interface and MLC for performance measurements.

DRAM: <https://gist.github.com/jboner/2841832> (see line 7).

See **Tiered Memory: Boost Virtual Machine Capacity and Lower TCO** ([intel.com](https://www.intel.com)) for more information.

⁴ See the solution brief at <https://www.intel.com/content/www/us/en/products/docs/memory-storage/optane-persistent-memory/vdi-solution-from-intel-and-nutanix-brief.html>

⁵ Claim [1] at <https://edc.intel.com/content/www/us/en/products/performance/benchmarks/intel-optane-persistent-memory-200-series/>

⁶ Claim [4] at <https://edc.intel.com/content/www/us/en/products/performance/benchmarks/intel-optane-ssd-p5800x-series/>

⁷ Claim [14] at <https://edc.intel.com/content/www/us/en/products/performance/benchmarks/intel-optane-ssd-p5800x-series/>

Performance results are based on testing as of dates shown in configurations and may not reflect all publicly available updates. See backup for configuration details. No product or component can be absolutely secure. Performance varies by use, configuration and other factors. Learn more at [intel.com/PerformanceIndex](https://www.intel.com/PerformanceIndex). Your costs and results may vary. Intel technologies may require enabled hardware, software or service activation. Intel, the Intel logo, and other Intel marks are trademarks of Intel Corporation or its subsidiaries.