SOLUTION BRIEF

Hybrid-Multicloud
Enterprise Container Platform

Building a Cloud-Native, Hybrid-Multicloud Infrastructure

Transform your business and get ready for hybrid-multicloud databases, artificial intelligence, and machine-learning workloads with Red Hat OpenShift Container Platform on Intel® technology

Red Hat OpenShift Container Platform

Solution Benefits

- **Simple scalability** from on-premises to the hybrid cloud helps enterprises easily accommodate additional changes in workload demands.
- **Advanced security features** with technologies designed to help keep data secure and help businesses protect data with minimal impact on speed.
- **High uptime** with advanced reliability, availability, and serviceability (RAS) features help facilitate recovery, which can reduce the frequency and cost of server downtime while protecting the integrity of mission-critical workloads.
- **Fewer service disruptions** can help lower total costs by reducing disruptions during drive swaps and providing LED management for faster status identification.

Executive Summary

Today's world is based on the hybrid cloud. Business interactions occur on-premises, through digital interaction, and through APIs. Today's cloud-native applications are hybrid too, with some workloads running in private clouds and others running in one or another public cloud. Hybrid cloud adoption is at 58 percent, and the majority (84 percent) of enterprises that use cloud computing have a multicloud strategy.[1]

Infrastructure modernization, automation, and cloud-native containers are important aspects of business transformation. The portability and repeatability of containers can create cost and resource savings, coupled with faster time to market and rapid innovation. Containers have little overhead, helping to lower hardware, maintenance, and licensing costs. They can be implemented quickly and components can be shared among containers.

Enterprises need high-performance data analytics and artificial intelligence (AI) to remain competitive. They require flexible solutions that can run traditional data analytics and AI applications. The solution described in this brief, co-developed by Intel and Red Hat, includes Intel® architecture-optimized AI libraries and tools—such as Intel® Math Kernel Library (Intel® MKL)-Deep Neural Networks and the Intel® Distribution for OpenVINO™—for developers along with validated, bundled containers for ease of DevOps deployment (for example, the Deep Learning Reference Stack). The solution helps enterprises modernize their data centers and start taking advantage of containers while lowering total costs. Based on Red Hat OpenShift Container Platform, the solution is available in Base and Plus configurations. This solution is specifically designed for a cloud-native, hybrid-multicloud infrastructure and is powered by the latest Intel® technologies. It includes AI tools optimized to run on 2nd Generation Intel® Xeon® Scalable processors. These processors feature built-in inferencing acceleration through Intel® Deep Learning Boost (Intel® DL Boost) with Vector Neural Network Instructions (VNNI). The platform is customizable and fully interoperable with existing infrastructure.

Enterprises can use this solution to increase their hybrid-multicloud adoption and quickly release new AI services with efficiency and scalability.

Modernize Infrastructure and Applications with Red Hat OpenShift Container Platform

Business transformation requires automation, containers, and a modern infrastructure. That's exactly what Red Hat OpenShift Container Platform (see Figure 1) provides, through a consistent, security-enabled, and managed Kubernetes cloud-native, hybrid-multicloud experience. A cloud-native infrastructure must accommodate a large, scalable mix of services-oriented applications and their dependent components. These applications and components are generally microservices-based, and the key to sustaining their operation is to have the right platform infrastructure.

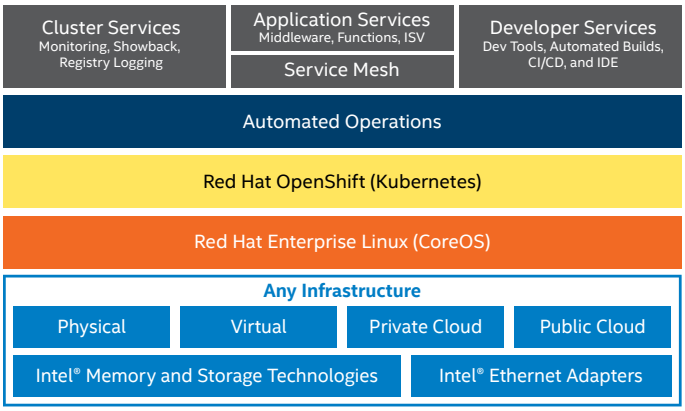


Figure 1. Enterprises can use Red Hat OpenShift Container Platform to develop, deploy, and manage innovative applications.

The solution documented here empowers enterprises to accelerate and automate the development, deployment, and management of portable and cloud-native hybrid applications. By taking full advantage of containers and automation without having to completely re-architect enterprise applications, application-development and IT operations teams gain the agility needed to develop cloud-native applications. They can also create and deploy portable applications with the speed and consistency that the business needs to stay ahead of the competition and drive new and increased revenue streams.[2]

Red Hat OpenShift Container Platform uses the Container Runtime Interface - Open Container Initiative engine and Kubernetes-based orchestration. It provides container-as-a-service and platform-as-a-service workflows for developers and existing applications. To simplify infrastructure management, Red Hat OpenShift Container Platform uses Red Hat OpenShift Container Storage, which is a Ceph-based Storage Manager. OpenShift Container Storage nodes can also serve as regular compute nodes.

Intel and Red Hat: Collaboration for Innovation

Intel and Red Hat have codeveloped deployable architecture solutions—including Intel® Select Solutions for Red Hat OpenShift Container Platform—for more than 20 years with the goal of accelerating enterprise digital transformation. From the moment a feature is on a product roadmap, Intel and Red Hat work to create hardware and software that interact synergistically, so that customers can make full use of the latest technology as it becomes available. Intel further supports that synergy by being active in OpenShift Commons. These are just some of the reasons that many Fortune 500 companies use Red Hat Enterprise Linux and that the majority of the world's data centers are powered by Intel® Xeon® processors.[3]

Reduce Total Costs while Increasing Flexibility in the Cloud-Native, Hybrid-Multicloud Infrastructure

This Intel® architecture-based solution for Red Hat OpenShift Container Platform delivers a turnkey, end-to-end solution using the latest Intel® technologies (see Figure 2) to deliver a production-ready foundation that simplifies hybrid-multicloud deployment, shares the latest best practices, and provides a stable, highly available environment for running production applications.

The solution helps to provision and deploy a highly available Red Hat OpenShift Container Platform cluster either on-premises or in a hybrid cloud with both the registry and the application pods backed by Red Hat OpenShift Container Storage. 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—thereby reducing total costs.

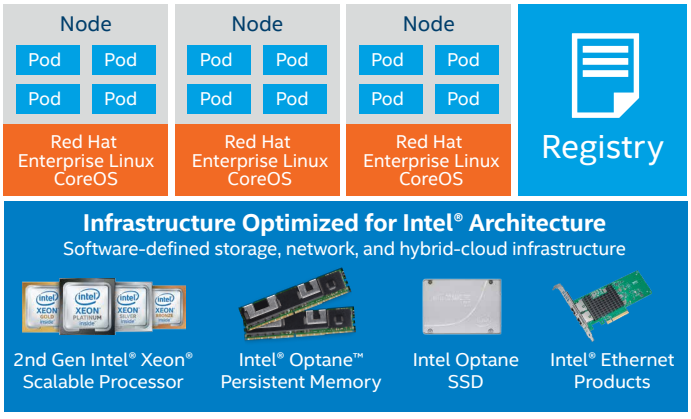


Figure 2. The Red Hat OpenShift Container Platform is optimized for Intel® technologies.

Accelerate and Simplify Application Development

Modern applications have a lot of moving parts, and there are many different concepts developers need to be aware of. This complexity can slow down innovation. OperatorHub (see Figure 3) is an easy-to-use catalog of operators (a method of packaging, deploying, and managing a Kubernetes-native application) from the Kubernetes community and Red Hat partners. Developers and Kubernetes administrators can use OperatorHub to gain automation advantages while enabling the portability of the services across Kubernetes environments. Developers can choose operators for a wide variety of tasks, including AI/ML, databases, integration and delivery, logging and tracing, monitoring, networking, security, storage, and streaming and messaging. Once installed on a cluster, operators are listed in the Red Hat OpenShift Container Platform Developer Catalog, providing a self-service experience. Developers don't need to be an expert in applications such as Ceph Object Storage, Kafka, Kubeflow, H2O Sparkling Water, Jupyterhub, Apache Spark, Seldon, Prometheus, Grafana, Argo, TensorFlow, or Scikit-learn—they just install the operators they need to accomplish their application goals. The end result is that teams can spend more time solving critical business needs and less on installing and maintaining infrastructure.

Open Data Hub is an integration of open source projects that provides a blueprint for building AI as a service on Red Hat OpenShift Container Platform. Open Data Hub makes it easier for developers to just jump in and start writing portable and cloud-native hybrid AI applications.

Easily Scale Your Workloads

The combination of Red Hat OpenShift Container Platform, Red Hat OpenShift Container Storage, Operator Hub, and Intel® technology makes it easy to scale a variety of workloads. These include enterprise and service provider workloads, such as enterprise applications, telecommunications service provider operations, and data analytics and AI/ML. The modular nature of the architecture enables developers to quickly add capacity, expand clusters, and extend capabilities. The reference architectures include predefined end-to-end hardware and software, meaning developers do not have to spend time determining which combination of technologies is best suited to their situation.

Efficient, Integrated AI Inferencing Optimized for Intel® Architecture

An integrated AI inferencing solution is layered on this foundation, which includes the Deep Learning Reference Stack, the Intel® Distribution for Python, and the Intel® Math Kernel Library (Intel® MKL) that use Intel® Deep Learning Boost (Intel® DL Boost) to provide acceleration for inference workloads. The Deep Learning Reference Stack includes additional optimized building blocks such as the Intel® Distribution of OpenVINO™ toolkit, and versions of TensorFlow and PyTorch optimized for Intel architecture—all of which can help accelerate the deployment of high-performance deep-learning inference models.

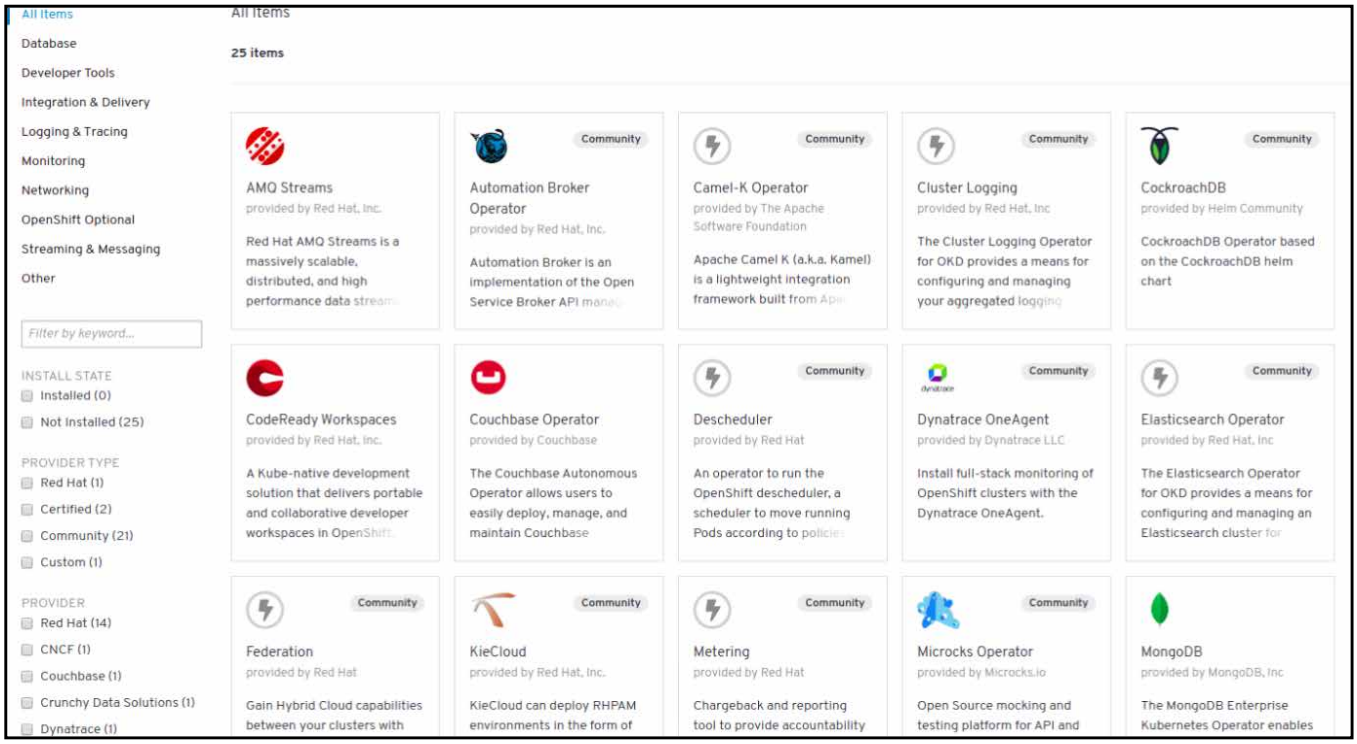


Figure 3. OperatorHub simplifies and speeds modern application development by providing easy access to many operators.

Meet Your Growing Storage Needs with Red Hat OpenShift Container Storage

As the amount of data explodes in every industry, storing and managing that data becomes increasingly challenging. In version 4.3 of the Red Hat OpenShift Container Platform, Red Hat OpenShift Container Storage is based on Ceph object storage (not Gluster storage). Ceph is ideal for handling the vast amounts of unstructured data that modern applications analyze. Intel and Red Hat are working with several OEMs to design Intel architecture-based Red Hat Ceph Storage reference architectures that simplify cluster configuration and deployment. These reference architectures take advantage of innovations in Intel® hardware, which are described in the next section.

Benefits of Running Red Hat OpenShift Container Platform on the Latest Intel® Technology

The solution developed by Red Hat and Intel combines 2nd Gen Intel Xeon Scalable processors, Intel® Optane™ persistent memory, Intel® Solid State Drive technology, and Intel® Ethernet Network Adapters with the Red Hat OpenShift Container Platform. The solution also includes enhanced capabilities around Red Hat OpenShift Container Platform to empower enterprises to quickly harness a reliable, comprehensive solution that delivers the following:

- **Simple scalability** from on-premises to the hybrid cloud helps enterprises easily accommodate additional changes in workload demands.
- **Advanced security features** with technologies designed to help keep data secure and help businesses protect data with minimal impact on speed.
- **High uptime** with advanced reliability, availability, and serviceability (RAS) features help facilitate recovery, which can reduce the frequency and cost of server downtime while protecting the integrity of mission-critical workloads.
- **Fewer service disruptions** can help lower total costs by reducing disruptions during drive swaps and providing LED management for faster status identification.

2nd Gen Intel® Xeon® Scalable Processors

- Offer high scalability for enterprise data centers.
- Deliver performance gains for virtualized infrastructure compared to previous-generation processors.
- Achieve exceptional resource utilization and agility.
- Enable improved data and workload integrity and regulatory compliance for data center solutions.
- The Intel® architecture-based solution for Red Hat OpenShift Container Platform features Intel Xeon Gold and Silver processors.

Hardware

Process Everything

Intel and Red Hat chose 2nd Gen Intel Xeon Scalable processors for this solution because they support demanding workloads, such as big data analytics. These workload-optimized processors also have built-in support for Intel Optane persistent memory and Intel DL Boost, which includes Vector Neural Network Instructions (VNNI).

- **Intel Optane persistent memory** is an innovative memory technology that delivers a unique combination of affordable large capacity and support for data persistence. This unique technology is comparable in speed to DRAM, and affordably delivers massive system memory expansion (in Memory Mode) when working with 2nd Gen Intel Xeon Scalable processors.
- **Intel DL Boost** extends the Intel® AVX-512 to accelerate AI and deep-learning inference workloads. Compute-intensive use cases such as voice recognition can significantly benefit from this new embedded AI acceleration technology—it can speed deep-learning inference throughput by up to 30X, compared to a previous generation Intel Xeon Scalable processor.[4]

Sample Use Case: Cloud-Native, Hybrid-Multicloud Data Analytics from Data Center Cloud to Edge

To illustrate the value of the Red Hat OpenShift Container Platform on Intel® technologies, consider the following example use case—an airline traffic control system that accurately predicts whether a flight will be on time by analyzing historical flight patterns using data analytics and artificial intelligence (AI). The example can be adapted to applications in other industries such as financial services, manufacturing, energy, or healthcare.

The examples illustrate the capabilities of the Red Hat OpenShift Container Platform including OperatorHub and OpenShift Container Storage. The petabytes of historical data can reside on large-capacity Intel® architecture-powered servers in the public cloud database (such as Amazon Web Services, Microsoft Azure, Google Cloud, or IBM Cloud). Regional data centers can pull portions of that data to train AI models (for example, using H2O Sparkling Water). Once the model is trained, it can be encapsulated with the Red Hat OpenShift Container Platform and deployed at every airport. The airports can choose to host their data center in a public cloud, a private cloud, or a hybrid cloud; on-premises; or at the edge. Airline analysts and customers can use the model to better understand flight patterns by making queries on the trained model, which uses the AI inferencing capabilities of 2nd Generation Intel® Xeon® Scalable processors, such as Intel® Deep Learning Boost, to deliver a better customer experience.

Store More

Intel and Red Hat selected a combination of Intel SSDs to power Red Hat OpenShift Container Platform (see Appendix A).

- Intel® SSD D3-S4510 Series and the Intel® SSD DC P4510 Series use Intel® 3D TLC NAND technology. The Intel SSD D3-S4510 Series offers high capacity and compatibility with existing SATA-based infrastructure, which can minimize the costs associated with modernizing the data center. The Intel SSD DC P4510 Series uses Non-volatile Memory Express (NVMe) over PCI Express (PCIe) to increase server agility and utilization and accelerate applications across a wide range of workloads. The P4510 also supports data-at-rest encryption and advanced manageability features, such as NVMe Management Interface (NVMe-MI). Sequential write throughput for the P4510 ranges from 1,100 to 2,900 MB/s (depending on drive size), compared to up to 560 MB/s for the S4510. Write latency for the P4510 is 18 µs, compared to 37 µs for the S4510.[5]
- An Intel Optane SSD DC P4800X is used for storage cache, handling the WAL and DB transactions. Intel Optane SSDs offer fast, predictable performance and excellent write endurance (up to 60 drive writes per day).[6]

Move Data Faster

The Intel® Ethernet 700 Series Network Adapters accelerate the delivery of new services and capabilities through intelligent offloads, sophisticated packet processing, quality open source drivers, and added bandwidth. These adapters can meet high-quality thresholds for data resiliency and service reliability for most media types and port speeds, and are backed by extensive testing, validation, and worldwide product support.[7,8,9,10]

By complementing 2nd Gen Intel Xeon Scalable processors with Intel SSDs and Intel Ethernet 700 Series adapters, the solution can help enterprises address storage bottlenecks and better utilize CPU resources. 10, 25, 40, and 100 GbE options can be deployed where necessary to help provide balanced system performance that scales well and delivers low latency.

Are You Ready for Multicloud?

A hybrid cloud is a computing environment that combines public cloud and private cloud environments. Data and applications can be shared between the two environments, enabling organizations to seamlessly scale on-premises infrastructure to off-premises infrastructure (and back).

Multicloud is the next evolutionary step that uses a combination of the best-of-breed solutions and services from different cloud providers, including private cloud, to create the most suitable solution for a business. According to Datamation, 58 percent of enterprises are already using two or more cloud providers.[11]

Deploying containerized applications and running them on an Intel® technology-optimized solution for Red Hat OpenShift Container Platform is an excellent way to modernize your infrastructure and prepare for multicloud. Most leading cloud service providers support running OpenShift.

Additional Intel® Technologies

Building on the Intel hardware foundation used for this solution, other Intel technologies integrated into Intel Xeon Scalable processors deliver additional performance, reliability, and security gains:

- **Intel® Platform Trust Technology or a discrete TPM 2.0** helps protect the system start-up process by helping to ensure the boot hardware is tamper-resistant and provides secured storage for sensitive data.
- **Intel® HT Technology** helps systems use processor resources more efficiently and increases processor throughput to improve overall performance on threaded software.
- **Intel® Turbo Boost Technology** accelerates processor and graphics performance for peak loads.
- **Intel® Speed Shift Technology** allows the processor to select its best operating frequency and voltage to deliver optimal performance and power efficiency.
- **Adaptive Double DRAM Device Correction** offers an innovative approach for managing errors to extend DIMM longevity.
- **Advanced Error Detection and Correction** helps improve fault coverage by identifying and correcting errors.
- **Local Machine Check Exception** helps localize handling of bad data consumption to the core that's executed on the bad data.

Cluster Configurations

This solution is available in two configurations: Base for standard workloads and Plus for more demanding workloads as shown in Appendix A. The solution may soon be extended to an Edge configuration. the Base and Plus configurations use Intel Optane persistent memory to deliver optimized workload performance for small production environments and larger enterprises and development-intensive use cases. The Plus configuration can scale when demand for resources grows.

Visit the Intel and Red Hat Solution Page at intel.com/redhat to learn more.

Learn More

- 2nd Generation Intel® Xeon® Scalable processors
- Intel® Optane™ DC persistent memory
- Intel® SSD Data Center Family
- Intel® Ethernet 700 Series Network Adapters
- Intel® Builders
- Twitter #IntelBuilders
- Intel and Red Hat Collaboration
- Red Hat OpenShift Container Platform

Appendix A: Bill of Materials for Configurations

This information is provided for Base and Plus architectures (see Tables A1-A2). Information that applies to all nodes in all configurations is provided in Table A3.

Table A1. The base configuration is suitable for small production environments. It consists of six to nine nodes depending on the workload (three control/master nodes, three to six compute/worker/storage nodes).

COMPONENT (PER NODE)	SPECIFICATIONS
3x Control/Master Nodes	
Processor	2x Intel® Xeon® Gold 5218 processor at 2.3 GHz (16 cores)
Memory	384 GB (12x 32 GB) (option to add 192 GB)
Persistent Memory	none
Boot Drive	2x Intel® SSD D3-S4510 Series 480 GB 2.5-inch RAID1
Container Registry Drive	1x Intel® SSD DC P4510 Series 4 TB or more
Storage Drive	1x Intel SSD DC P4510 Series 4 TB or more
Storage Cache	1x Intel® Optane™ SSD DC P4800X 375 GB (for write-ahead log [WAL] and database [DB])
Network	1x 10 GbE Intel® Ethernet Network Adapter X710-DA2 dual-port or above (25 GbE recommended)
Management Network	1 GbE
3x-6x Compute/Worker/Storage Nodes (depending on workload)	
Processor	2x Intel® Xeon® Gold 6248 processor at 2.5 GHz (20 cores)
Memory	384 GB (12x 32 GB)[a]
Intel® Optane™ Persistent Memory	1.5 TB (12x 128 GB)
Boot Drive	2x Intel® SSD D3-S4510 Series 480 GB 2.5-inch RAID1
Storage Drive	4x Intel® SSD DC P4510 Series 4 TB or more
Network	1x 25 GbE Intel® Ethernet Network Adapter XXV710-DA2 dual-port or above
Management Network	1x 10 GbE Intel® Ethernet Network Adapter X710-DA2 dual-port or above

[a] Can be reduced to 192 GB to be used as cache if using 1 TB of Intel® Optane™ persistent memory in Memory Mode.

Table A2. The plus configuration is suitable for high-availability production environments. It consists of 15 nodes (three control/master nodes and 12 hyperconverged compute/worker/storage nodes).

INGREDIENT (PER NODE)	SPECIFICATION
3x Control/Master Nodes	
Processor	2x Intel® Xeon® Gold 5218 processor at 2.3 GHz (16 cores)
Memory	384 GB (12x 32 GB) (option to add 192 GB)
Persistent Memory	none
Boot Drive	2x Intel® SSD D3-S4510 Series 480 GB 2.5-inch RAID1
Container Registry Drive	1x Intel® SSD DC P4510 Series 4 TB or more
Storage Drive	1x Intel SSD DC P4510 Series 4 TB or more
Storage Cache	1x Intel® Optane™ DC P4800X 375 GB (for write-ahead log [WAL] and database [DB])
Network	1x 10 GbE Intel® Ethernet Network Adapter X710-DA2 dual-port or above (25 GbE recommended)
Management Network	1 GbE
12x Compute/Worker/Storage Nodes	
Processor	2x Intel® Xeon® Gold 6248 processor at 2.5 GHz (20 cores)
Memory	384 GB (12x 32 GB)[a]
Intel® Optane™ Persistent Memory	1.5 TB (12x 128 GB)
Boot Drive	2x Intel® SSD D3-S4510 Series 480 GB 2.5-inch RAID1
Storage Drive	4x Intel® SSD DC P4510 Series 4 TB or more
Network	1x 25 GbE Intel® Ethernet Network Adapter XXV710-DA2 dual-port or above
Management Network	1x 10 GbE Intel® Ethernet Network Adapter X710-DA2 dual-port or above

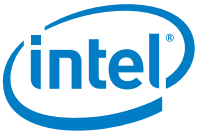
[a] Can be reduced to 192 GB to be used as cache if using 1 TB of Intel® Optane™ persistent memory in Memory Mode.

Table A3. Software and Other Details that Apply to All Nodes and All Configurations

BASTION NODE CONFIGURATION	
Processor	2x Intel® Xeon® Silver 4114 processor at 2.2 GHz (10 cores)
Memory	250 GB
Boot Drive	2x Intel® SSD D3-S4610 Series 480 GB 2.5-inch RAID1
Storage Drive	4x Intel SSD D3-S4610 Series 1.6 TB U.2
Network	25 GbE
NETWORK TOP-OF-RACK CONFIGURATION	
Management	Switch: 1x Arista Ports: 48x RJ45 1GbE 1U
Data	Switch: 1x Arista Ports: 18x SFP28 10/25GbE, 4x 100 GbE 1U
SOFTWARE STACK	
Red Hat OpenShift Container Platform	v4.3
Red Hat OpenShift Container Storage	v4.3
Kubernetes	v1.16
H2O.io Driverless AI	v1.8.0
Spark	2.4.5
H2O Sparkling Water	3.28.0.3-1-2.4
Kafka	v2.3
SQL Database	Microsoft SQL Server 2019-GA
Deep Learning Reference Stack	Latest version (clearlinux.org/stacks/deep-learning)
FIRMWARE/SOFTWARE CONFIGURATION	
Trusted Platform Module (TPM)	TPM 2.0 discrete or firmware TPM—Intel® Platform Trust Technology (Intel® PTT)
Intel® Technologies	Intel® Hyper-Threading Technology (Intel® HT Technology) enabled Intel® Turbo Boost Technology enabled Intel® Speed Shift technology, Hardware P-states (HWP) native Intel Turbo Boost Technology/HWP energy performance preference (EPP)/energy performance bias (EPB) settings balanced Three-way mirroring, with the least overhead on processing power[a] Updated to all available patches[b]

[a] Recommended but not required.
[b] Although not strictly required, we recommend that customers apply all pertinent Intel® technology errata as frequently as possible.

Solution Provided By:



[1] Hosting Tribunal, "25 Must-Know Cloud Computing Statistics in 2020." hostingtribunal.com/blog/cloud-computing-statistics/#gref

[2] IDC. "The Business Value of Red Hat OpenShift." Sponsored by Red Hat. October 2016. openshift.com/sites/default/files/idc-business-value-of-openshift.pdf.

[3] GeekWire. "Why someone needs to step up and challenge Intel in the data center chip market." May 2018. geekwire.com/2018/someone-needs-step-challenge-intel-data-center-chip-market.

[4] Configurations: Tested by Intel as of February 26, 2019. Platform: Dragon rock 2 socket Intel® Xeon® Platinum 9282 processor (56 cores per socket), HT ON, Turbo ON, total memory 768 GB (24 slots/32 GB/2933 MHz), BIOS: SE5C620.86B.0D.01.0241.112020180249, Centos 7 Kernel 3.10.0-957.5.1.el7. x86_64, Deep Learning Framework: Intel® Optimization for Caffe version: github.com/intel/caffe d554cbf1, ICC 2019.2.187, MKL DNN version: v0.17 (commit hash: 830a10059a018cd-2634d94195140cf2d8790a75a), model: github.com/intel/caffe/blob/master/models/intel_optimized_models/int8/resnet50_int8_full_conv.prototxt, BS=64, No datalayer DummyData: 3x224x224, 56 instance/2 socket, Datatype: INT8 vs Tested by Intel as of July 11, 2017: 2S Intel® Xeon® Platinum 8180 processor @ 2.50 GHz (28 cores), HT disabled, Turbo disabled, scaling governor set to "performance" via intel_pstate driver, 384GB DDR4-2666 ECC RAM. CentOS Linux release 7.3.1611 (Core), Linux kernel 3.10.0-514.10.2.el7.x86_64. SSD: Intel® SSD DC S3700 Series (800 GB, 2.5in SATA 6 Gb/s, 25nm, MLC).

Performance measured with: Environment variables: KMP_AFFINITY='granularity=fine, compact', OMP_NUM_THREADS=56, CPU Freq set with cpupower frequency-set -d 2.5G -u 3.8G -g performance. Caffe: revision f96b759f71b2281835f690af267158b82b150b5c. Inference measured with "caffe time --forward_only" command, training measured with "caffe time" command. For "ConvNet" topologies, dummy dataset was used. For other topologies, data was stored on local storage and cached in memory before training. Topology specs from github.com/intel/caffe/tree/master/models/intel_optimized_models (ResNet-50), Intel C++ compiler ver. 17.0.2 20170213, Intel® MKL small libraries version 2018.0.20170425. Caffe run with "numactl -l".

[5] Product specifications for Intel® SSD DC P4510 Series and Intel® SSD D3-S4510 Series: ark.intel.com/content/www/us/en/ark/compare.html?productIds=122579,122580,122573,134924,134920.

[6] Intel product brief: intel.com/content/www/us/en/solid-state-drives/optane-ssd-dc-p4800x-brief.html

[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 are 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.

[8] The Intel® Ethernet 700 Series is backed with global support infrastructure for customers pre- and post-sales.

[9] 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.

[10] The Intel® Ethernet 700 Series supported speeds include 10 GbE, 25 GbE, 40 GbE, and 100 GbE.

[11] Datamation, May 2019, "Cloud Survey: The Rise of Multicloud Computing." datamation.com/cloud-computing/cloud-survey-the-rise-of-multicloud-computing.html.