intel®

Intel® Select Solutions for Red Hat OpenShift Container Platform*

Accelerate the path to an enterprise-grade container solution with an optimized, performance-verified solution.

intel® select solution

Disrupt or be disrupted. This is the reality facing companies like yours, now and in the future. In fact, 30 percent of Fortune 500* companies are predicted to be out of business in 30 years.[1] The reason: those companies will have failed to successfully transform their businesses. They will have failed to modernize their IT infrastructures to support rapid delivery of new applications and services. They will have failed to stay innovative and competitive.

Keeping your business innovative and competitive means keeping it agile, which demands scaling IT. That requires a modern data center with modern applications and processes that take advantage of modern technologies, such as containers, microservices, the hybrid cloud, and more.

Containers, for instance, can lead to both cost and resource savings, coupled with a faster time to market and rapid innovation to meet your business needs and growth. They provide an operating system (OS)-level virtualization method to deploy and run distributed applications and microservices with little overhead. They are quick to implement, and components can be shared among containers. The portability and repeatability of containers enable fast iteration and development. Containers are also lightweight and consume few resources, which can help lower your hardware costs and reduce maintenance and licensing costs.

The process of researching and deploying a modern data center—or even an individual container solution and the infrastructure needed to run it—however, can take a lot of time: time you might not be able to afford to lose.

To help enterprises, including yours, modernize the data center and start taking advantage of containers, Intel and Red Hat have codeveloped Intel® Select Solutions for Red Hat OpenShift Container Platform*. These solutions are optimized to run an on-premises, private container platform that is customizable and fully interoperable with existing infrastructure and environments. They are tested and verified by Intel and Red Hat, so enterprises can spend less time researching infrastructure and simply implement a leading open source container solution powered by the latest Intel® hardware. Solutions can be deployed in about an hour instead of the typical six hours, so your enterprise can quickly start driving digital transformation through agile DevOps and release new services to market faster, more efficiently, and at scale.[2]

Red Hat OpenShift Container Platform

Red Hat OpenShift Container Platform is one of the leading security-enabled, comprehensive enterprise-grade container-application platforms available. It empowers enterprises to accelerate and automate the development, deployment, and management of innovative applications. By taking full advantage of containers without having to completely re-architect enterprise applications,

application-development and IT-operations teams gain the agility needed to develop more applications and major features per year. They can also create and deploy apps with the speed and consistency that the business needs to stay ahead of the competition and drive new and increased revenue streams.[3]

Red Hat OpenShift Container Platform is based on an industry-standard Docker* runtime environment and Kubernetes* orchestrator. It provides container-as-a-service (CaaS) and platform-as-a-service (PaaS) workflows for developers and existing applications.

Intel Select Solutions for Red Hat OpenShift Container Platform

Intel Select Solutions for Red Hat OpenShift Container Platform help optimize price/performance while significantly reducing infrastructure evaluation time. Components are handpicked to be workload-optimized for dev-test use cases, and they are verified to perform. The pre-validated selection of software and hardware components is designed to meet the demands of running containers. The systems also provide the capabilities and agility needed to eliminate the need for multiple single-purpose systems. In addition, key system characteristics are verified to perform for the solutions at all levels.

Intel Select Solutions for Red Hat OpenShift Container Platform combine the Intel® Xeon® Scalable processor platform, Intel® Solid State Drive (SSD) technology, and Intel® Ethernet Network Adapters with the latest Red Hat* Enterprise Linux* operating system—including enhanced capabilities around Red Hat OpenShift Container Platform—to empower enterprises to quickly harness a reliable, comprehensive solution that delivers:

- **Advanced security features** with technologies designed to keep data secure and help businesses protect data without compromising speed

- **High uptime with advanced reliability, availability, and serviceability (RAS) features** that facilitate recovery, which can reduce the frequency and cost of server downtime while protecting the integrity of mission-critical workloads

- **Fewer service disruptions** to help lower total cost of ownership (TCO) by reducing disruptions during drive swaps and providing LED management for faster status identification

- **Simple scalability** when a service needs to be scaled, enabling you to easily handle additional loads by increasing the number of pods

Hardware Selections

Intel and Red Hat chose Intel Xeon Gold processors for Intel Select Solutions for Red Hat OpenShift Container Platform because these processors support the most demanding workloads.

Intel and Red Hat also chose the Intel SSD DC S4500 Series, the Intel® Ethernet 700 Series of network adapters, and the Intel SSD DC P4500 Series for Intel Select Solutions for Red Hat OpenShift Container Platform. The Intel SSD DC S4500 Series offers high capacity, so that enterprise data centers can achieve performance benefits over traditional hard-disk drives (HDDs) while increasing data stored per rack unit. The Intel SSD DC S4500 Series enables hot tiering for cloud-native storage using Red Hat OpenShift Container Storage*, which increases efficiency and agility and can help reduce costs.
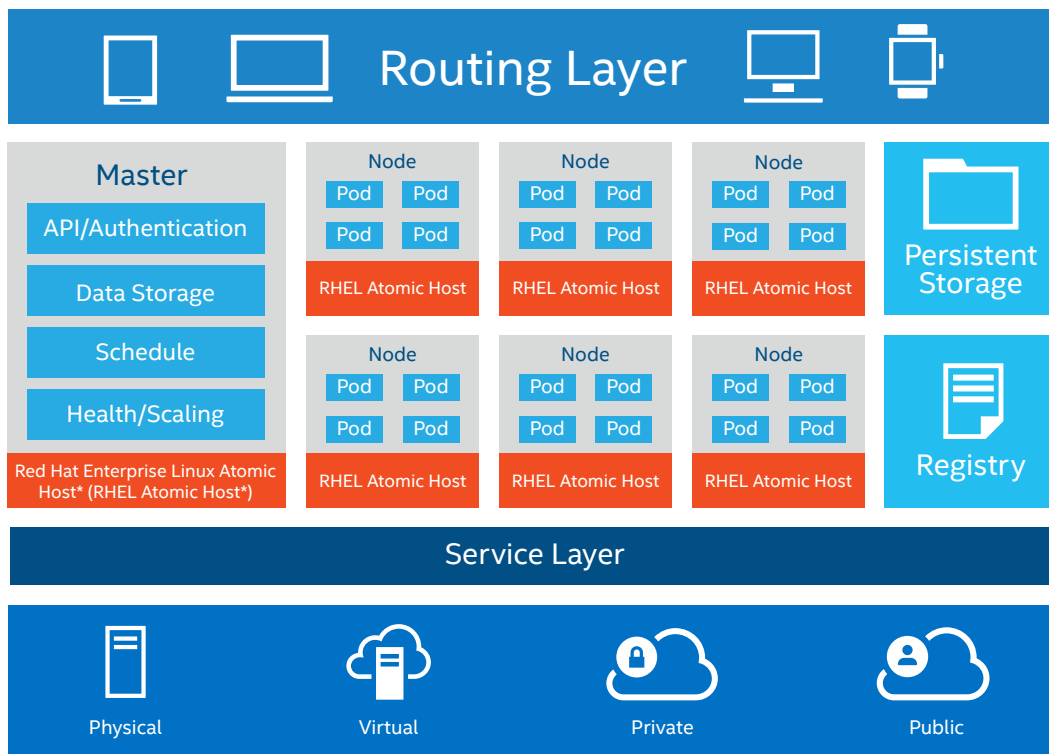

Figure 1. Architecture overview of Intel® Select Solutions for Red Hat OpenShift Container Platform*

The Intel SSD DC P4500 Series further enhances Intel Select Solutions for Red Hat OpenShift Container Platform by including an entirely new NVM Express* (NVMe*) controller, support for data-at-rest encryption, and advanced manageability features, such as NVMe Management Interface* (NVMe-MI*).

The Intel Ethernet 700 Series of network adapters accelerates the delivery of new services and capabilities through intelligent offloads, sophisticated packet processing, quality open source drivers, and added bandwidth. The Intel Ethernet 700 Series also delivers validated performance, is ready to meet high quality thresholds for data resiliency and service reliability for most media types and port speeds, and is backed by extensive testing, validation, and worldwide product support.[4,5,6,7]

By complementing Intel Xeon Scalable processors with the Intel SSD DC 4500 Series and Intel Ethernet 700 Series, Intel Select Solutions for Red Hat OpenShift Container Platform can further help your enterprise address storage bottlenecks and better utilize CPU resources. 10, 25, 40, and 100 gigabit Ethernet (GbE) options can be deployed where necessary to help ensure balanced system performance that scales well and delivers low latency.

Verified Performance through Benchmark Testing

All Intel Select Solutions are verified through benchmark testing to meet a prespecified minimum capability level of workload-optimized performance. For Intel Select Solutions for Red Hat OpenShift Container Platform, Intel and Red Hat chose to use the Magento Open Source* with Apache JMeter* benchmark methodology to set those performance levels.

Magento*

Magento is a leading open source e-commerce platform that is ideally suited for use on the Red Hat OpenShift Container Platform. It is important to be able to test and measure the actual capabilities of the servers hosting your application. As such, Magento provides a performance toolkit with a set of metrics that can be used to judge the performance and overall load capacity of your servers. Intel and Red Hat used these metrics in setting performance levels for Intel Select Solutions for Red Hat OpenShift Container Platform.

Apache JMeter*

The Apache JMeter open source load-generator software provides a standardized benchmark test. It runs a series of simulated operations of an online storefront across different cloud services in order to evaluate cloud service providers against a common measure. While designed for testing web applications, Apache JMeter is suited for testing the functional behavior and measuring the performance of a Magento site, including average response times and average throughput and error counts.

Magento 2.2.2 and Apache JMeter 4.0 were used as the baseline versions in testing Intel Select Solutions for Red Hat OpenShift Container Platform. More information on how to benchmark a Magento site with Apache JMeter can be found at upcloud.com/support/benchmark-magento-with-jmeter/.

What Are Intel® Select Solutions?

Intel Select Solutions are verified hardware and software stacks that are optimized for specific software workloads across compute, storage, and network. The solutions are developed from deep Intel experience with industry solution providers, in addition to extensive collaboration with the world's leading data center and service providers.

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

1. Follow the software and hardware stack requirements outlined jointly by Red Hat and Intel (see **Appendix A**)

2. Replicate or exceed Intel's reference benchmark-performance threshold

3. Publish a detailed implementation guide to facilitate customer deployment

Solution providers can develop their own optimizations to add further value to their solutions.

Intel and Red Hat

Intel and Red Hat have codeveloped deployable architecture solutions—including Intel® Select Solutions for Red Hat OpenShift Container*—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 synergy in how the hardware and software interact, 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* and by being a Platinum Member of the OpenStack Foundation*.

These are just some of the reasons that 90 percent of Fortune 500* companies use Red Hat* Enterprise Linux* and the majority of the world's data centers are powered by Intel® Xeon® processors.[9,10]

New Service Deployment

Intel and Red Hat also established a standard for the minimum time required to deploy new services with Intel Select Solutions for Red Hat OpenShift Container Platform. That standard minimum is 60 minutes. Find a complete list of performance standards in Appendix A.

Base and Plus Configurations

Intel Select Solutions for Red Hat OpenShift Container Platform are available in two configurations: "Base" and "Plus," as shown in Appendix A. The Base configuration specifies the minimum required performance capability for Intel Select Solutions for Red Hat OpenShift Container Platform. The Plus configuration provides one example of how system

builders, system integrators, and solution and service providers can further optimize the solution to achieve higher performance and capabilities. The Plus solution is also designed for larger enterprises and development-intensive use cases. For example, the Plus configuration can support 2.25x more concurrent workloads and 1.9x more concurrent users, with 2x faster response times, compared to a Base configuration.[8]

Technology Selections for Intel Select Solutions for Red Hat OpenShift Container Platform

In addition to the Intel hardware foundation used for Intel Select Solutions for Red Hat OpenShift Container Platform, Intel technologies integrated in Intel Xeon Scalable processors deliver further performance, reliability, and security gains:

- **Intel® Platform Trust Technology (Intel® PTT) or a discrete Trusted Platform Module (TPM) 2.0:** Protects the system start-up process by ensuring the boot hardware is tamper-free and provides secured storage for sensitive data.

- **Intel® Hyper-Threading Technology (Intel® HT Technology):** Ensures that 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 (ADDDC):** Offers an innovative approach in managing errors to extend DIMM longevity.

- **Advanced Error Detection and Correction (AEDC):** Improves fault coverage by identifying and correcting errors.

- **Local Machine Check Exception (LMCE):** Helps improve performance.

Intel® Xeon® Scalable Processors

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

Intel Select Solutions for Red Hat OpenShift Container Platform* feature Intel Xeon Silver processors and Intel Xeon Gold processors.
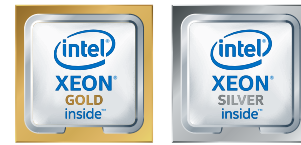
Accelerate Application Development and Delivery with Intel Select Solutions for Red Hat OpenShift Container Platform

Intel Select Solutions for Red Hat OpenShift Container Platform deliver a turnkey, end-to-end solution using the latest Intel technologies to deliver a production-ready foundation that simplifies the deployment process, shares the latest best practices, and provides a stable, highly available environment on which to run your production applications. The solution helps in provisioning and deploying a highly available OpenShift Container Platform cluster on a private cloud environment with both the registry and the application pods backed by Red Hat OpenShift Container Storage. Proven to scale with 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 Ethernet 700 Series: **: intel.com/ethernet**

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

Intel and Red Hat: **redhat.com/en/partners/intel**

Red Hat OpenShift Container Platform: **redhat.com/en/technologies/cloud-computing/openshift**

Appendix A: The Base and Plus Configurations for Intel Select Solutions for Red Hat OpenShift Container Platform

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 minimum benchmark-performance thresholds listed below.

Intel Select Solutions for Red Hat OpenShift Container Platform include separate specifications for the control-plane node and application nodes. The Base configuration consists of a single node for storage. The Plus configuration demonstrates scalability through a three-node storage cluster.

INGREDIENT	INTEL® SELECT SOLUTIONS FOR RED HAT OPENSHIFT CONTAINER PLATFORM* **BASE CONFIGURATION**	INTEL SELECT SOLUTIONS FOR RED HAT OPENSHIFT CONTAINER PLATFORM **PLUS CONFIGURATION**
CONTROL-PLANE NODE (BASTION NODE + THREE MASTER NODES + TWO INFRASTRUCTURE NODES)		
PLATFORM	6 x Intel® Server Board S2600WFT or the OEM's chosen platform	6 x Intel Server Board S2600WFT or the OEM's chosen platform
PER-PLATFORM COMPONENTS		
PROCESSOR	2 x Intel® Xeon® Silver 4114 processor (2.20 GHz, 10 cores, 20 threads) or a higher number Intel Xeon Scalable processor	2 x Intel Xeon Silver 4114 processor (2.20 GHz, 10 cores, 20 threads) or a higher number Intel Xeon Scalable processor
MEMORY	192 GB or higher (12 x 16 GB DDR4-2400)	192 GB or higher (12 x 16 GB DDR4-2400)
BOOT DRIVE**	2 x Intel® SSD DC S4500 Series (M.2 or 2.5-inch) RAID1	2 x Intel SSD DC S4500 Series (M.2 or 2.5-inch) RAID1
STORAGE HOST BUS ADAPTER (HBA) CONTROLLER PER NODE**	Intel® RAID Module RMSP3HD080E	Intel RAID Module RMSP3HD080E
REMOTE MANAGEMENT MODULE PER NODE**	Intel® Remote Management Module 4 Lite 2 AXXRMM4LITE2	Intel Remote Management Module 4 Lite 2 AXXRMM4LITE2
DATA NETWORK PER NODE**	10 Gb Intel® Ethernet Connection X722 with the Intel® Ethernet Converged Network Connection OCP X527-DA2 (X527DA2OCPG1P5) or 10 Gb Intel® Ethernet Converged Network Adapter X710, dual-port SFP+ ML2*d	10 Gb Intel Ethernet Converged Network Adapter X710, dual-port SFP+ ML2 or 25 Gb Intel Ethernet Converged Network Adapter XXV710-DA2, dual-port SFP28
MANAGEMENT NETWORK PER NODE	Integrated 1 GbE	Integrated 1 GbE
MINIMUM OF FOUR APPLICATION NODES		
PLATFORM	4 x Intel Server Board S2600WFT or the OEM's chosen platform	4 x Intel Server Board S2600WFT or the OEM's chosen platform
PROCESSOR	2 x Intel Xeon Silver 4114 processor (2.20 GHz, 10 cores, 20 threads) or a higher number Intel Xeon Scalable processor	2 x Intel Xeon Gold 6138 processor (2.60 GHz, 14 cores, 28 threads) or a higher number Intel Xeon Scalable processor
MEMORY	256 GB or higher (8 x 32 GB DDR4-2400)	256 GB or higher (8 x 32 GB DDR4-2400)
BOOT DRIVE**	2 x Intel SSD DC S4500 Series (M.2 or 2.5-inch) RAID1	2 x Intel SSD DC S4500 Series (M.2 or 2.5-inch) RAID1
STORAGE HBA CONTROLLER PER NODE**	Intel RAID Module RMSP3HD080E	Intel RAID Module RMSP3HD080E
REMOTE MANAGEMENT MODULE PER NODE**	Intel Remote Management Module 4 Lite 2 AXXRMM4LITE2	Intel Remote Management Module 4 Lite 2 AXXRMM4LITE2
DATA TIER PER NODE**	1 x 4 TB Intel SSD DC P4500 Series (NVM Express* [NVMe*])	1 x 4 TB Intel SSD DC P4500 Series (NVMe)

DATA NETWORK PER NODE**	10 Gb Intel Ethernet Connection X722 with the Intel Ethernet Converged Network Connection OCP X527-DA2 (X527DA2OCPG1P5) or 10 Gb Intel Ethernet Converged Network Adapter X710, dual-port SFP+ ML2	10 Gb Intel Ethernet Converged Network Adapter X710, dual-port SFP+ ML2 or 25 Gb Intel Ethernet Converged Network Adapter XXV710-DA2, dual-port SFP28
MANAGEMENT NETWORK PER NODE	Integrated 1 GbE	Integrated 1 GbE
MINIMUM OF THREE STORAGE NODES		
PLATFORM	3 x Intel Server Board S2600WFT or the OEM's chosen platform	3 x Intel Server Board S2600WFT or the OEM's chosen platform
PROCESSOR	2 x Intel Xeon Gold 5115 processor (2.20 GHz, 10 cores, 20 threads) or a higher number Intel Xeon Scalable processor	2 x Intel Xeon Gold 6138 processor (2.60 GHz, 14 cores, 28 threads) or a higher number Intel Xeon Scalable processor
MEMORY	256 GB or higher (8 x 32 GB DDR4-2400)	256 GB or higher (8 x 32 GB DDR4-2400)
BOOT DRIVE**	2 x Intel SSD DC S4500 Series (M.2 or 2.5-inch) RAID1	2 x Intel SSD DC S4500 Series (M.2 or 2.5-inch) RAID1
STORAGE HBA CONTROLLER PER NODE**	Intel RAID Module RMSP3HD080E	Intel RAID Module RMSP3HD080E
STORAGE EXPANDER NODE**	Intel® Storage Expander RES3TV360	Intel Storage Expander RES3TV360
REMOTE MANAGEMENT MODULE PER NODE**	Intel Remote Management Module 4 Lite 2 AXXRMM4LITE2	Intel Remote Management Module 4 Lite 2 AXXRMM4LITE2
DATA TIER PER NODE	16 x 3.8 TB Intel SSD DC S4500 Series 2.5-inch (Serial ATA [SATA])	16 x 3.8 TB Intel SSD DC S4500 2.5-inch (SATA)
DATA NETWORK PER NODE**	10 Gb Intel Ethernet Connection X722 with the Intel Ethernet Converged Network Connection OCP X527-DA2 or 10 Gb Intel Ethernet Converged Network Adapter X710, dual-port SFP+ ML2	10 Gb Intel Ethernet Converged Network Adapter X710, dual-port SFP+ ML2 or 25 Gb Intel Ethernet Converged Network Adapter XXV710-DA2, dual-port SFP28
SOFTWARE		
	Red Hat* Enterprise Linux* (RHEL*) and RHEL Atomic Host* Red Hat OpenShift Container Platform* Red Hat container-native storage iPXE* environment Red Hat Ansible* automation HAProxy*	

APPLIES TO ALL NODES		
MANAGEMENT NETWORK PER NODE	Integrated 1 GbE	Integrated 1 GbE
TRUSTED PLATFORM MODULE (TPM)	TPM 2.0 discrete or firmware TPM (Intel® Platform Trust Technology [Intel® PTT])	TPM 2.0 discrete or firmware TPM (Intel PTT)
FIRMWARE AND SOFTWARE OPTIMIZATIONS	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** Updated to all available patches** Keepalived* (open source)	Intel HT Technology enabled Intel Turbo Boost Technology enabled Intel Speed Shift technology, HWP native Intel Turbo Boost Technology/HWP EPP/EPB settings balanced Three-way mirroring, with the least overhead on processing power** Updated to all available patches** Keepalived (open source)

MINIMUM PERFORMANCE STANDARDS
Verified to meet or exceed the following minimum performance capabilities:

MINIMUM NUMBER OF MAGENTO* INSTANCES WORKLOADS DEPLOYED TO ALL APPLICATION NODES	32	72
NUMBER OF SYSBENCH* PODS (DEPLOYED TO TWO INFRASTRUCTURE NODES)	32	72
MINIMUM NUMBER OF CONCURRENT USERS (APACHE JMETER* BENCHMARK [USER WEB TRAFFIC] DEPLOYED TO BASTION NODE)	725	1,400
APPLICATION THROUGHPUT (AVERAGE NUMBER OF TRANSACTIONS PER SECOND)	310	620

BUSINESS VALUE OF CHOOSING A PLUS CONFIGURATION OVER A BASE CONFIGURATION

The Plus configuration can support 2.25x more concurrent workloads and 1.9x more concurrent users, with 2x faster response times, compared to a Base configuration.[8]

**Recommended, not required

¹ JobTraQ. "Transform or Die: 30% of Fortune 500 Will Not Exist in 10 Years." 2017. jobtraq.com/blog/transform-or-die-30-of-fortune-500-will-not-exist-in-30-years.html.

² Intel. "Introducing a Fully Integrated Turnkey Solution from Intel and Red Hat." 2017. https://builders.intel.com/docs/cloudbuilders/introducing-a-fully-integrated-turnkey-solution-from-intel-and-red-hat.pdf. Configuration details: Master nodes: three Lenovo System x3550 M5* servers with Intel® Xeon® processor E5-2680 v4, 128 GB RAM, and two 150 GB Intel® SSD DC S3520 Series drives in RAID 1 configuration. Infrastructure nodes: two Lenovo System x3550 M5 servers with Intel Xeon processor E5-2620 v4, 128 GB RAM, and one 150 GB Intel SSD DC S3520 Series drive in RAID 1 configuration. Worker nodes: six Lenovo System x3550 M5 servers with Intel Xeon processor E5-2680 v4, 384 GB RAM, and two 150 GB Intel SSD DC S3520 Series drives in RAID 1 configuration. Bastion: one Lenovo System x3550 M5 server with Intel Xeon processor E5-2620 v4, 128 GB RAM, and two 150 GB Intel SSD DC S3520 Series drives in RAID 1 configuration; this node provides the runtime environments for containers and has the required services to be managed by the master. This node also has the required services to run pods, including Docker*, a kubelet, and a service proxy.

³ 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.

⁴ 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*.

⁵ The Intel® Ethernet 700 Series is backed with global support infrastructure for customers pre- and post-sales.

⁶ 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.

⁷ The Intel® Ethernet 700 Series supported speeds include 10 GbE, 25 GbE, 40 GbE, and 100 GbE.

⁸ Intel internal testing as of July 30, 2018. **Base configuration:** *one bastion node, three master nodes, and two infrastructure nodes*: 2 x Intel® Xeon® Silver 4114 processor, Intel® Server Board S2600WFT, total memory: 192 GB, 12 slots/16 GB/2,400 megatransfers per second (MT/s) DDR4 RDIMM, Intel® Hyper-Threading Technology (Intel® HT Technology) enabled, Intel® Turbo Boost Technology enabled; storage (boot): 2 x 200 GB Intel® SSD DC S3710 M.2 SATA; network devices: 1 x dual-port 25 Gb Intel® Ethernet Network Adapter XXV710, network speed: 25 GbE, ucode: 0x043, OS/software: bastion node: Red Hat* Enterprise Linux* (RHEL 7.5*); master and infrastructure nodes: RHEL Atomic Host 7.5.1*. *Four application nodes*: 2 x Intel Xeon Silver 4114 processor, Intel Server Board S2600WFT, total memory: 256 GB, 8 slots/32 GB/2,400 MT/s DDR4 RDIMM, Intel HT Technology enabled, Intel Turbo Boost Technology enabled; storage (boot): 2 x 200 GB Intel SSD DC S3710 M.2 SATA, storage (data tier): 1 x 4 TB Intel SSD DC P4500; network devices: 1 x dual-port 25 Gb Intel Ethernet Network Adapter XXV710, network speed: 25 GbE, ucode: 0x043, OS/software: RHEL Atomic Host 7.5.1. *Three storage nodes*: 2 x Intel Xeon Gold 5115 processor, Intel Server Board S2600WFT, total memory: 256 GB, 8 slots/32 GB/2,400 MT/s DDR4 RDIMM, Intel HT Technology enabled, Intel Turbo Boost Technology enabled; storage (boot): 2 x 200 GB Intel SSD DC S3710 M.2 SATA, storage (data tier): 10 x 3.8 TB Intel SSD DC S4500 SATA; network devices: 1 x dual-port 25 Gb Intel Ethernet Network Adapter XXV710, network speed: 25 GbE, ucode: 0x043, OS/software: RHEL Atomic Host 7.5.1. **Plus configuration:** *one bastion node, three master nodes, and two infrastructure nodes*: 2 x Intel Xeon Silver 4114 processor, Intel Server Board S2600WFT, total memory: 192 GB, 12 slots/16 GB/2,400 MT/s DDR4 RDIMM, Intel HT Technology enabled, Intel Turbo Boost Technology enabled; storage (boot): 2 x 200 GB Intel SSD DC S3710 M.2 SATA; network devices: 1 x dual-port 25 Gb Intel Ethernet Network Adapter XXV710, network speed: 25 GbE, ucode: 0x043, OS/software: RHEL Atomic Host 7.5.1. *Four application nodes*: 2 x Intel Xeon Gold 6138 processor, Intel Server Board S2600WFT, total memory: 256 GB, 8 slots/32 GB/2,400 MT/s DDR4 RDIMM, Intel HT Technology enabled, Intel Turbo Boost Technology enabled; storage (boot): 2 x 200 GB Intel SSD DC S3710 M.2 SATA, storage (data tier): 1 x 4 TB Intel SSD DC P4500; network devices: 1 x dual-port 25 Gb Intel Ethernet Network Adapter XXV710, network speed: 25 GbE, ucode: 0x043, OS/software: RHEL Atomic Host 7.5.1. *Three storage nodes*: 2 x Intel Xeon Gold 6138 processor, Intel Server Board S2600WFT, total memory: 256 GB, 8 slots/32 GB/2,400 MT/s DDR4 RDIMM, Intel HT Technology enabled, Intel Turbo Boost Technology enabled; storage (boot): 2 x 200 GB Intel SSD DC S3710 M.2 SATA, storage (data tier): 16 x 3.8 TB Intel SSD DC S4500 SATA; network devices: 1 x dual-port 25 Gb Intel Ethernet Network Adapter XXV710, network speed: 25 GbE, ucode: 0x043, OS/software: RHEL Atomic Host 7.5.1.

⁹ Based on Red Hat client data from 2013. Source: Red Hat. "Meet Business Goals with Intel and Red Hat." 2016.

¹⁰ 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/.