White Paper

Virtualized Broadband Network Gateways (vBNGS)

netElastic vBNG Reaches 1 Tbps[1] Throughput in Tests with Intel

Using 4th Gen Intel® Xeon® Scalable Processor-based servers, the vBNG saw a 46% throughput improvement in only 2RU of rack space

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Internet access has helped create the connected world and provides a significant economic growth driver that delivers a wide range of services touching nearly every aspect of modern life. But some 20 million to 40 million Americans don't have quality Internet access, shutting them out of these opportunities.

The US Government is helping and that's driving a push by internet service providers (ISPs) to build out a network to support greater connectivity. In legislation passed in 2022, the US government provided $65 billion over 10 years to expand Internet access and close the gap of those who currently don't have access. As ISPs look to build out their network to meet these goals, a critical piece of infrastructure is the broadband network gateway.

Broadband Network Gateway Defined

A BNG aggregates data traffic between multiple home and office customers providing access to the ISP's core network services and out to the internet. BNGs are located at the edge of the network and must have the packet processing performance to authorize and authenticate users and look up and implement policies on a per user basis and then to forward those packets from broadband access networks to the backbone network.

Until recently, BNGs required specialized hardware to achieve required performance. But the maturity of networks functions virtualization (NFV) has enabled virtual BNGs (vBNGs) with the performance to tackle very high-speed networks.

netElastic, an Intel® Network Builders ecosystem member worked with Intel to maximize the performance of its vBNG using Intel® architecture-based servers to show that this technology has competitive performance and can scale. Using the systems under test (SUT) and test procedure described below, the companies were able to record throughput of 1 Terabit per second (Tbps)[1] in a 2RU (rack unit), two-socket server.

A Pioneering vBNG

The netElastic vBNG is a pioneering solution that is scalable, flexible and relies on commercial-off-the-shelf (COTS) hardware which means it costs less than an alternative with fixed function hardware.

The netElastic vBNG provides subscriber management services and supports all common BNG access features including PPPoE, IPoE, and LAC/LNS, subscriber traffic policing and shaping, and optional carrier-grade network address translation (CGNAT). Full routing protocol support includes leading network protocols such as MPLS, OSPF, BGP, and others.

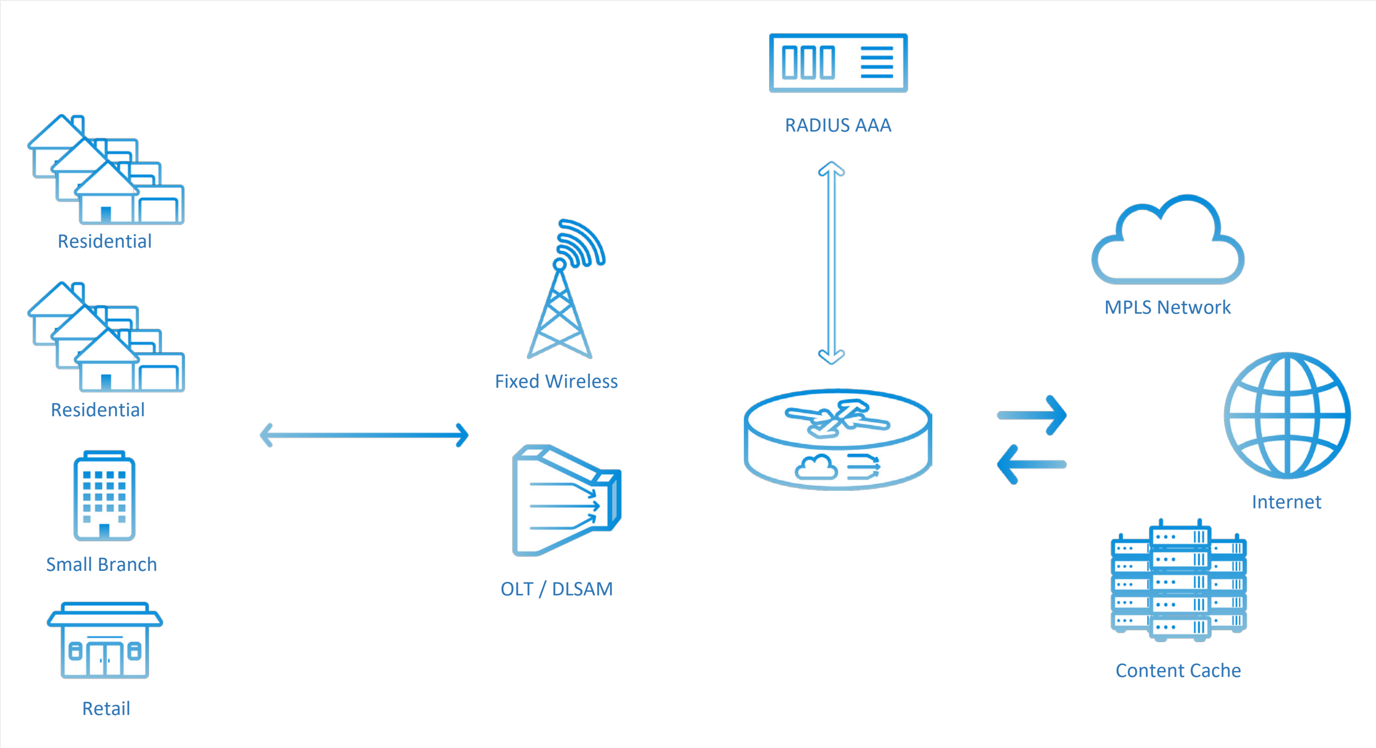

Figure 1. Typical application for netElastic vBNG.

The netElastic vBNG software utilizes a software-defined networking (SDN) architecture that separates the control plane and data plane functions, which allows each to be run on their own separate hosts or virtual machines. By separating the control plane and data plane, both can be scaled independently, providing maximum deployment flexibility. The netElastic vBNG's SDN architecture also improves network flexibility and simplifies infrastructure management with software-based control.

Figure 1 shows the netElastic vBNG in a typical application. The vBNG instance is fronted by an optical line terminal (OLT), digital subscriber line access multiplexer (DSLAM) or fixed wireless access point, that terminates access traffic and then uses multiplexing to physically aggregate the traffic coming from multiple subscribers. The vBNG applies policies to each packet from the RADIUS authentication, authorization and accounting (AAA) server before forwarding the packets to the resources on the core network including the Internet, corporate WAN connections, streaming content caches or others.

4th Gen Intel Xeon Scalable Processors

For the tests, the companies utilized servers powered by 4th Gen Intel Xeon Scalable processors. The CPU family is designed to accelerate performance across the most demanding workloads. The processor's architecture combines high-performance processor cores with up to eight built-in accelerators[2] to help maximize performance efficiency for demanding workloads.

4th Gen Intel Xeon Scalable processors offer a breakthrough in I/O capabilities, with up to 80 lanes of PCIe 5.0 connectivity and Intel® Scalable I/O Virtualization for more virtual machines per server.

Security features built into the CPUs offer multi-tenant security for flexible deployments, including Intel® Software Guard Extensions (Intel® SGX) and Intel® Total Memory Encryption. The processors are also ruggedized for performance in extreme environments. Intel Xeon Scalable processors have a long track record of providing stability and reliability in rugged, high-demand environments.

For the vBNG application, the availability of single instruction multiple data (SIMD) is valuable because it improves CPU performance by applying the same operations across multiple data lanes. Network-optimized 4th Gen Intel Xeon processors are the next step in accelerating load balancing workloads while increasing energy efficiency, with a high-throughput, low-latency platform engineered for data centers, network core, and scalable to the edge for on-prem or cloud deployments.

Integration of accelerators into the processor redefines CPU architecture and brings a less complex board design, reduced power consumption and performance advantages. Figure 2 shows some of the built-in accelerators.

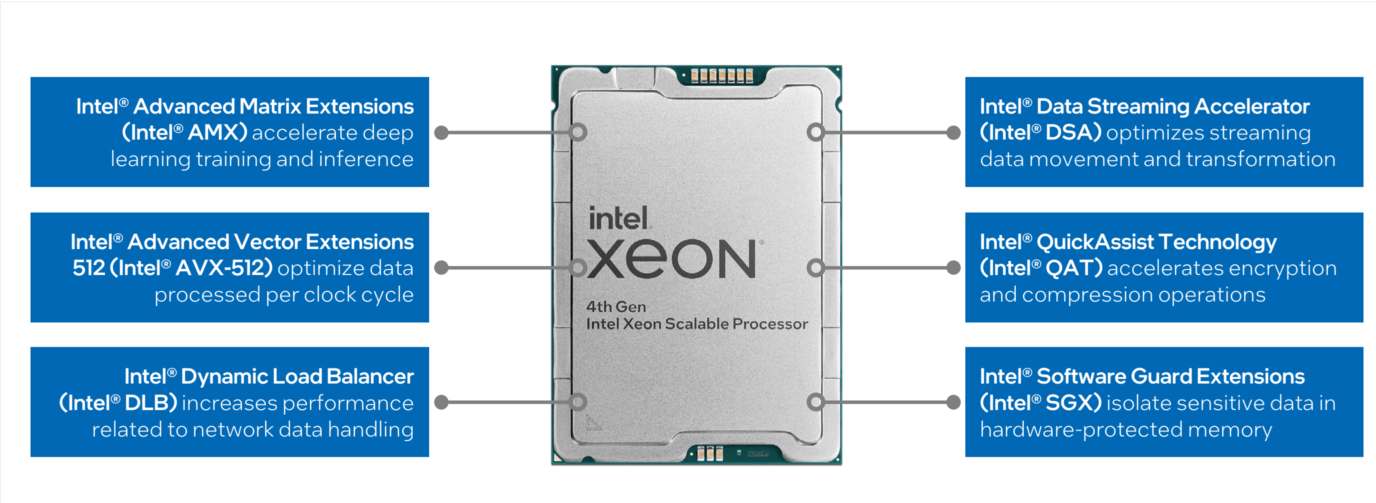

Figure 2. Key accelerators built into the 4th Gen Intel Xeon Scalable processor.

The systems under test also made use of the Intel Ethernet Network Adapter E810-2CQDA2. Dynamic Device Personalization (DDP) is an important feature in this adapter for the vBNG application. DDP enables customizable packet filtering on the more common broadband access protocols (QinQ and PPPoE) for more efficient packet processing. Also important is receive side scaling (RSS) which enables efficient distribution of network packets across multiple CPUs in multiprocessor systems.

Test Setup Consists of Three Configurations

The test set up can be seen in Figure 3. Two netElastic vBNG instances are set up on a single server with one vBNG per CPU socket. On the subscriber side, up to 128,000 devices are emulated with a PPPoX client, for Config 3 (Table 1 below), 192,000 devices were supported with six network-network interfaces (NNI) and six user-network interfaces (UNI). Intel® Ethernet 800 Series Network Adapters offer multiple ports of 100GbE connectivity to the provider vBNG. On the provider network side, more than 100,000 OSPF routes are emulated for IPv4-based Ethernet traffic and 150,000 OSPF routes are supported for Config 3.

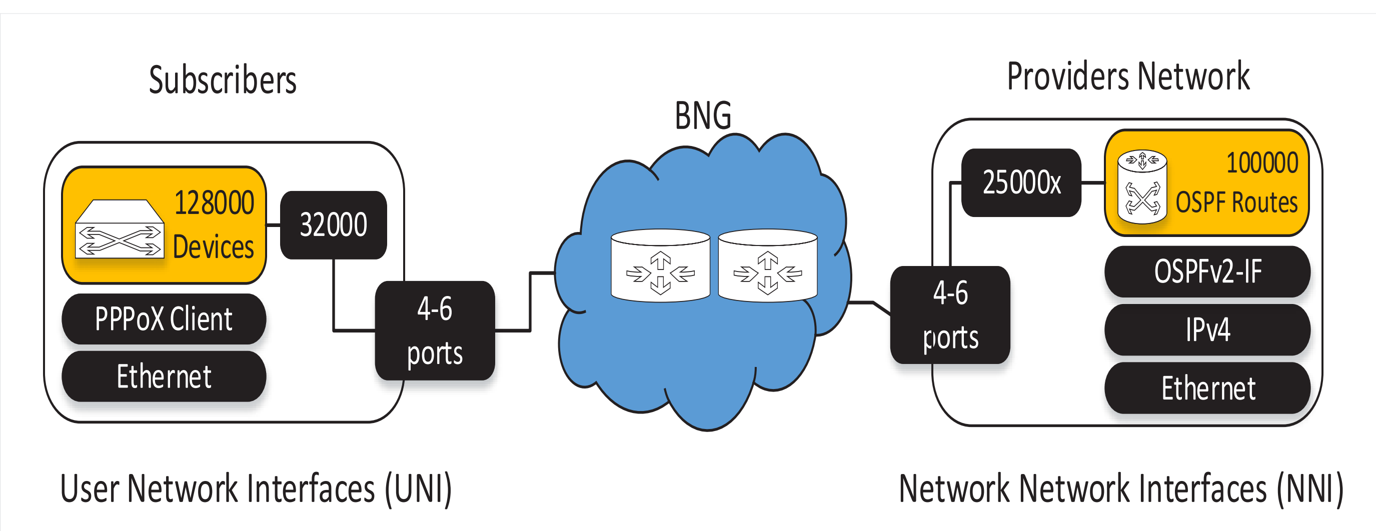

Figure 3. Test network showing vBNG instances for both the subscriber network and the providers' network.

	Config 1 2S Intel® Xeon® 8360Y 250W 2U Form Factor	Config 2 2S Intel® Xeon® 8470N 300W 2U Form Factor	Config 3 2S Intel® Xeon® 8470N 300W 2U Form Factor
CPU Generation	3rd Gen Intel Xeon Scalable	4th Gen Intel Xeon Scalable	4th Gen Intel Xeon Scalable
Network Throughput/2RU-High Server	800Gbps	800Gbps	1 Tbps
Data Plane Processing (Number of vCPU Threads)	136	136	172
Control Plane Processing & Main Thread	2	2	10
Internal Thread	2	2	2
VM OS vCPU Threads	2	2	2
Host vCPU Threads	2	66	22
Total Threads/Server	144	208	208
Number of 100GbE User Network Interfaces (UNI)	4	4	6
Number of 100GbE Network-Network Interfaces (NNI)	4	4	6

Table 1. Three test configurations (complete specifications are shown in the addendum).

Three systems under test (SUT) were configured in order to show performance improvement across CPU generations as well as for the same generation of CPUs with more network connections. Config 1 is the same set up as Config 2 except it uses 3rd Generation Intel Xeon Scalable 8360Y processors. The difference between Config 2 and Config 3 is the use of four 100Gbps interfaces vs six interfaces, respectively. This allows Config 2 to be the same throughput as Config 1, while Config 3 is configured to demonstrate the full throughput capacity of the Intel® Xeon® 8470N processor. Each of the configurations are shown in Table 1.

The tests were conducted using larger size packets - 256 bytes to 1024 bytes - that represent traffic patterns that reflect current network streaming and other high data rate uses. netElastic estimates that 80% of its residential vBNG traffic consists of large-packet sizes falling into this range.

	Config 1 2S Intel® Xeon® 8360Y 250W 2U Form Factor	Config 2 2S Intel® Xeon® 8470N 300W 2U Form Factor	Config 3 2S Intel® Xeon® 8470N 300W 2U Form Factor
# NNI	4	4	6
# UNI	4	4	6
# OSPF Routes	100,000	100,000	150,000
# Subscribers	128,000	128,000	192,000

Table 2. Networking functionality for each test configuration.

Tests Show Raw Performance and Gen-over-Gen Improvement

Two sets of tests were run, the first of which was a test of raw performance where all three vBNG configurations were measured for how much data they could forward at various packet sizes before their packet losses crossed a threshold of 0.001 of the data flow. Table 2 shows additional networking details about the server configurations.

The results of this test are shown in Figure 4. As can be seen, Config 3 reached 1 Tbps of performance at 1024 byte packet sizes.

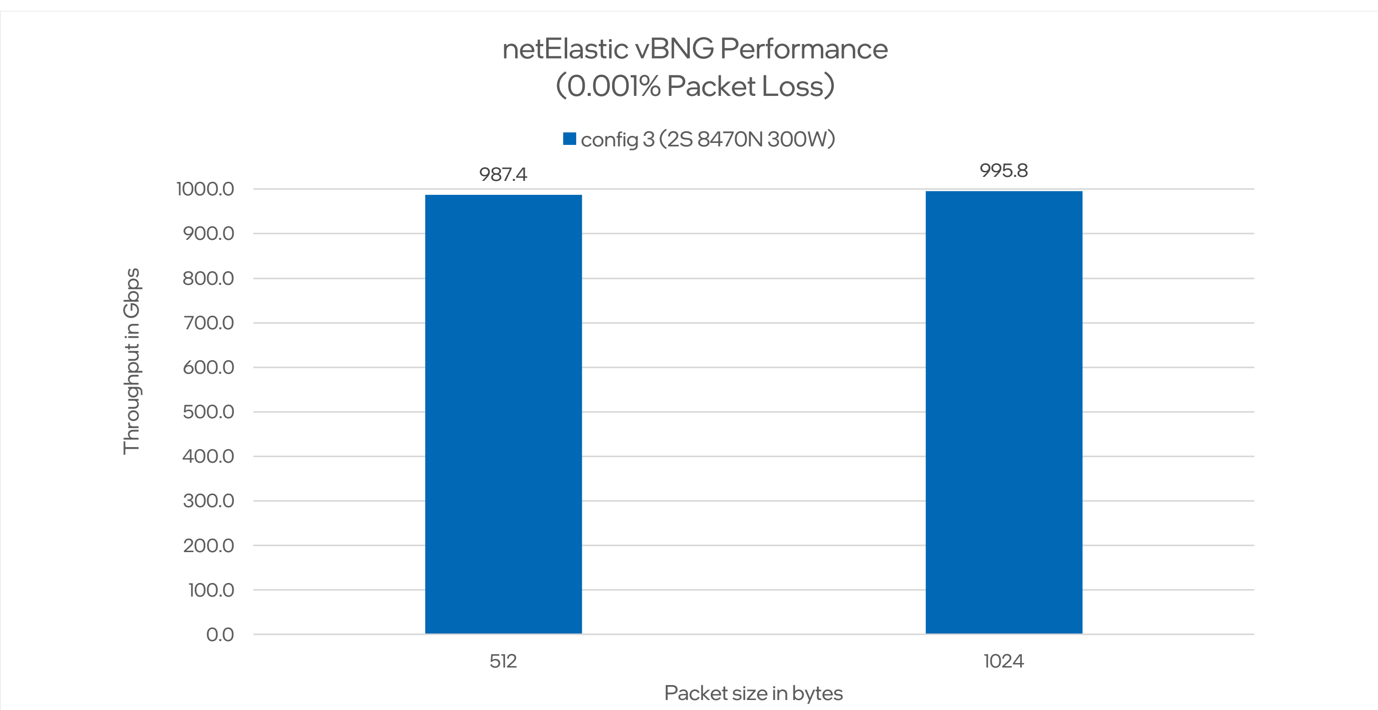

Figure 4. Results of performance tests for config 3 vBNG test configurations (higher is better).

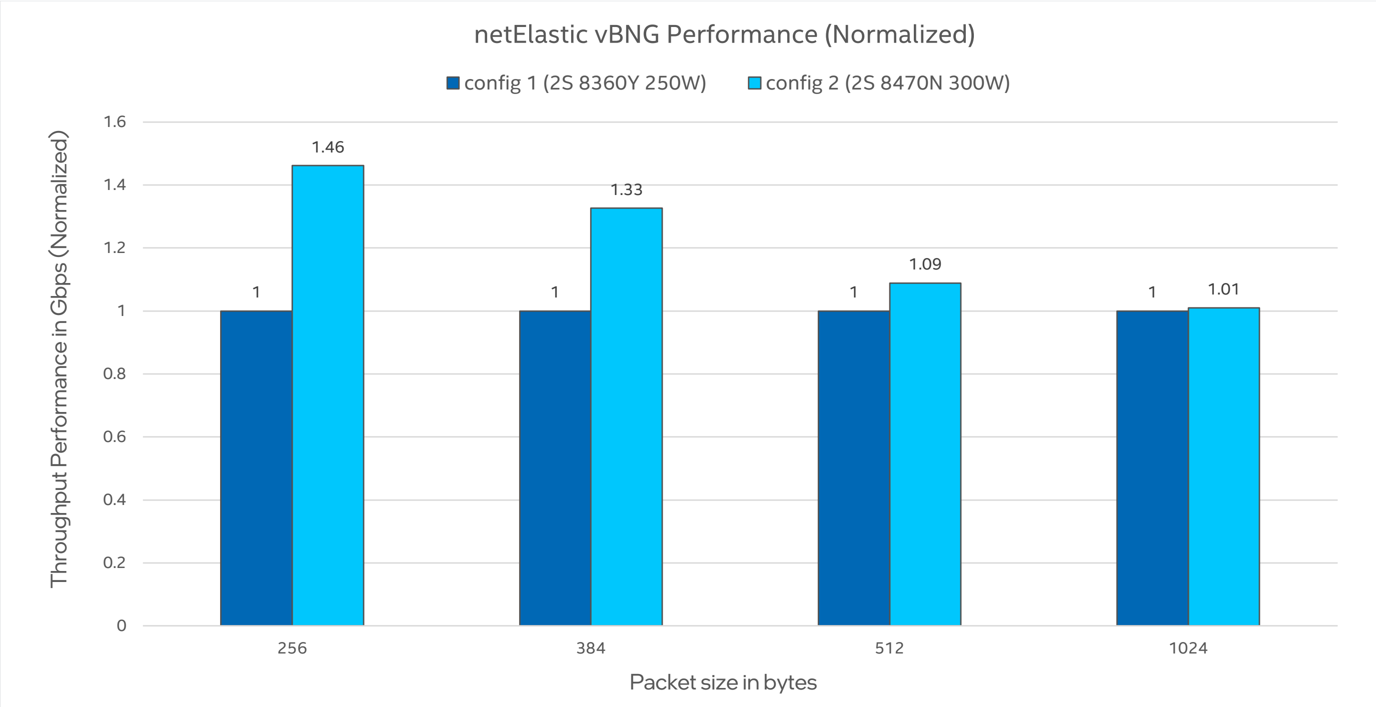

Figure 5. Gen-over-gen performance results for Config 1 and Config 2 (higher is better).

Test two shows the gen-over-gen performance improvements between Config 1 and Config 2. As can be seen in Figure 5, up to 46% improvement can be seen with 256 byte packet sizes from the dual socket 3rd Gen Intel Xeon Scalable Processor 8360Y that powers Config 1 compared to dual socket 4th Gen Intel Xeon Scalable Processor 8470N that powers Config 2.

Conclusion

While not all service providers need 1Tbps BNGs today, these tests are important to show that vBNGs are high performance and can scale as network throughput grows. The raw performance test demonstrated that at 1024 byte packets, performance can reach 1 Tbps on a 2RU-high server powered by 4th Gen Intel Xeon Scalable processor with eight ports of 100GbE and 4 ports of 50GbE provided by the Intel Ethernet 800 Series Network Adapters .

The tests also showed that a 4th Gen Intel Scalable Processor can deliver 46% better performance (at 256 byte packet sizes) than a 3rd Gen Intel Scalable Processor-based server with a similar configuration. With these performance levels, the netElastic vBNG should be considered alongside traditional proprietary hardware-based BNGs when maximum performance and scalability is needed.

Learn More

netElastic vBNG

4th Generation Intel® Xeon® Scalable Processors

Intel® Network Builders

Intel® Ethernet Network Adapter E810

[1] Tests conducted by Intel on Dec. 7 & 8, 2022; system and software configurations are in the addendums at the end of this document.

[2] https://www.intel.com/content/www/us/en/products/details/processors/xeon/scalable.html-- SPR

ADDENDUM: SUT Configurations

	Config 1 2S Intel® Xeon® 8360Y 250W	Config 2 2S Intel® Xeon® 8470N 300W	Config 3 2S Intel® Xeon® 8470N 300W
Name	Intel Xeon Platinum 8360Y	Intel Xeon Platinum 8470N	Intel Xeon Platinum 8470N
Testing Date/Time	Thu Dec 8 01:11:52 UTC 2022	Wed Dec 7 10:34:01 PM UTC 2022	Wed Dec 7 10:34:01 PM UTC 2022
System	Intel Corporation Coyote Pass	Quanta S6Q SDP	Quanta S6Q SDP
CPU Model	Intel® Xeon® Platinum 8360Y	Intel® Xeon® Platinum 8470N	Intel® Xeon® Platinum 8470N
Sockets	2	2	2
Cores per Socket	36	52	52
Hyperthreading	Enabled	Enabled	Enabled
CPUs	144	208	208
Intel Turbo Boost	Disabled	Disabled	Disabled
Base Frequency	2.4GHz	1.7GHz/2.1 for Intel SST-PP Level 4	1.7GHz/2.1 for Intel SST-PP Level 4
All-core Maximum Frequency	3.1GHz	2.7GHz	2.7GHz
Maximum Frequency	3.5GHz	3.6GHz	3.6GHz
NUMA Nodes	2	2	2
Accelerators	NA	QAT:8, DSA:8, IAA:0, DLB:8	QAT:8, DSA:8, IAA:0, DLB:8
Installed Memory	512GB (16x32GB 3200 MT/s)	512GB (32x16GB 4400 MT/s)	512GB (32x16GB 4400 MT/s)
Hugepagesize	320	320	320
Transparent Huge Pages	madvise	madvise	madvise
Automatic NUMA Balancing	Disabled	Disabled	Disabled
Network Adapter	4x Intel E810 2CQDA2	2x Intel Ethernet Network Adapter E810-2CQDA2 6x Intel Ethernet Network Adapter E810-CQDA2	2x Intel Ethernet Network Adapter E810-2CQDA2 6x Intel Ethernet Network Adapter E810-CQDA2
Disk	1.8 TiB NVME	465.8G NVME	465.8G NVME
BIOS	SE5C6200.86B.0020.P34.2107301450		
Microcode	0xd000363	0x2b000111	0x2b000111
OS	Red Hat 8.6	Red Hat 8.6	Red Hat 8.6
Kernel	4.18.0-372.19.1.el8_6.x86_64	4.18.0-372.19.1.el8_6.x86_64	4.18.0-372.19.1.el8_6.x86_64
TDP	250 watts	300 watts	300 watts

ADDENDUM: Software Configuration

	config 1 (2S 8360Y 250W)	config 2 (2S 8470N 300W)	config 3 (2S 8470N 300W)
Workload & version	netElastic vBNG-xeon-release 1.11.55	netElastic vBNG-xeon-release 1.11.55	netElastic vBNG-xeon-release 1.11.55
Compiler	gcc version 8.5.0 20210514 (Red Hat 8.5.0-10) (GCC)	gcc version 8.5.0 20210514 (Red Hat 8.5.0-10) (GCC)	gcc version 8.5.0 20210514 (Red Hat 8.5.0-10) (GCC)
Libraries			
VM OS and version	3.10.0-862.el7.x86_64	3.10.0-862.el7.x86_64	3.10.0-862.el7.x86_64
Traffic Generator Type	IXIA	IXIA	IXIA
Packet Loss Setting (%)	0.001	0.001	0.001