Solution Brief

Casa Systems, Intel Achieve Terabit vBNG Performance[1]

In tests conducted by Intel, Axyom vBNG running on a single-socket 4th Gen Intel® Xeon® Scalable-based server showed throughput of 540 Gbps – extensible to 1 Tbps on a dual-socket server[1]

In order to meet the continually increasing throughput and drive to reduce power consumption for software defined networking (SDN) and network function virtualization (NFV) use cases, Intel and Casa Systems, Inc., have been working jointly to address the challenge for virtualized broadband gateway (vBNG).

The testing done for this paper utilizes 4th Gen Intel® Xeon® Scalable processors that provide several feature enhancements specifically targeted for networking workloads. These include Intel® 800 Series Network Adapters enhancements for processing broadband access traffic, support for PCIe Gen5, along with improved Intel® Advanced Vector Extensions 512 (Intel® AVX-512) performance. All greatly aid with the high-speed data plane processing requirements associated with vBNGs.

This solution brief describes the impacts of these CPU features on a vBNG, a key virtual network function (VNF) workload for broadband aggregation that requires not only high throughput and resiliency, but also power consumption efficiency.

Specifically, this document highlights the performance of the Casa Axyom™ vBNG workload on a single socket 4th Gen Intel Xeon Scalable Processor platform, generating up to 540 Gbps per CPU at less than 0.001% packet loss with variable power consumption based on the operating workload[1].

vBNG Defined

A BNG is typically deployed by a communications service provider (CoSP) in a central office (CO) or at edge locations close to end users. The BNG aggregates data traffic to and from multiple home and office locations while providing access to the core of the network and internet services. The portion of the network connecting to home and office locations is referred to as the access network, or last mile, while the portion of the network connecting to data centers is referred to as the core network, or mid mile. Packets emanating from the access network destined for the core network are collectively referred to as upstream (US) or uplink (UL) traffic. Packets emanating from the core network destined for the access network are collectively referred to as downstream (DS) or downlink (DL) traffic.

In terms of typical broadband access protocols, the network cards on the BNG server must be capable of supporting IP-over-Ethernet (IPoE) traffic patterns. Upstream traffic typically consists of 802.1Q (Q-in-Q) encapsulated IPv4 or IPv6 packets consisting of an outer service provider VLAN (S-VLAN) tag and an inner customer VLAN (C-VLAN) tag that allow routing to specific locations within the access network. The ratio of downstream to upstream traffic typically favors downstream traffic and oftentimes ranges from 8:1 to 9:1 for the DL:UL traffic mix.

Additional traffic shaping is typically performed by BNGs in order to implement specific quality-of-service (QoS) levels along with differentiated services for specific subscribers. Bandwidth rate limiting may be performed in order to differentiate specific tiers of subscribers, for example home versus office locations, customers that may pay for higher data rates, as well as higher priority traffic classes carrying data from VoIP, gaming or other real-time services. BNG deployments also typically include support for firewalls and ACLs in order to limit not only which access network locations can connect to the BNG, but also which TCP/UDP ports are allowed within the access network or home.

Historically, BNGs have been deployed as fixed function hardware. However, with the advent of networks functions virtualization (NFV), virtual (vBNGs) have emerged as virtual network functions (VNF) orchestrated and deployed in a virtual machine (VM). With cloud native containerization also maturing, vBNGs became containerized, or able to run as a container network function (CNF) that has been orchestrated and deployed in a container pod. Deploying virtualized or containerized appliances allows for running the VNF/CNF on standard dual socket Intel® architecture (IA) server.

Casa Pioneers CUPS-based vBNG

Casa Systems Axyom vBNG solution enables the evolution toward a cloud native distributed BNG using control and user plane separation (CUPS), as shown in Figure 1, compliant with the TR-459 specification from the Broadband Forum. Casa is a pioneer in the field of CUPS-based vBNG starting its product development and commercialization in 2018. Casa's vBNG products offer subscriber scalability and high throughput on disaggregated commercial-off-the-shelf (COTS) hardware with Intel® Xeon® Scalable CPUs.

The Casa vBNG supports Wireline Wireless Convergence (WWC) standards to deliver quality of service, redundancy and operational efficiency across both network types. To this effort, Casa brings knowledge from the company's deep wireless research and development, where the benefits of CUPS were well understood, to optimize the use of CUPS in the vBNG solutions. The result is that both control and user planes can run as separate components and can be deployed on the same server or on different servers in different locations.

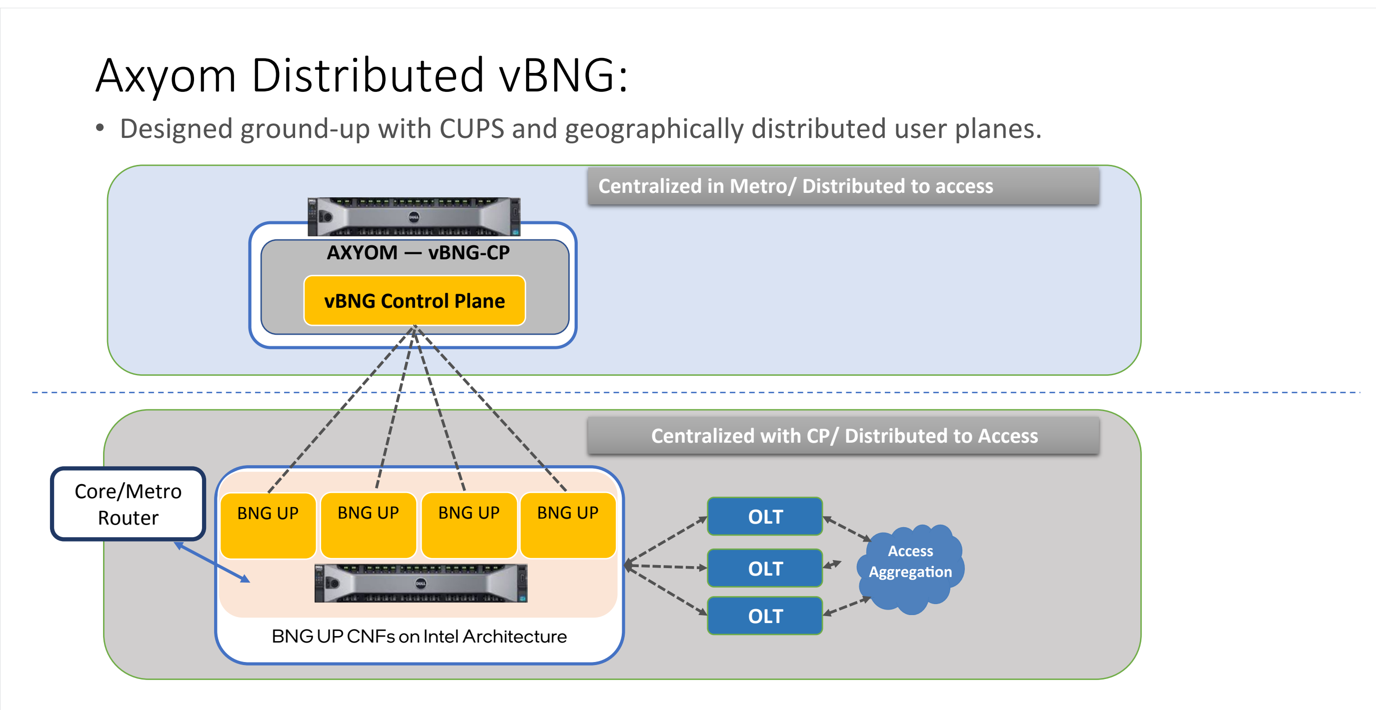


Figure 1. Casa Axyom distributed vBNG – control and user plane separation (CUPS). Source – Casa Systems

vBNG Performance Test Set Up

The server under test (SUT) complex (Figure 2) is composed of one Intel® Xeon® Platinum 8480+ Processor, which terminates 800GbE of I/O provided by 4x200GbE Intel Ethernet Network Adapters E810-2CQDA2. The platform is capable of processing 800GbE of data. The full server configuration and workload is shown in the tables and in sections 1.1 and 1.2.

Using a typical 8:1 asymmetrical broadband access profile, Intel and Casa completed testing of the Casa Axyom BNG on an Intel® Xeon® Platinum 8480+ Processor modular single-socket reference design server showing a combined uplink and downlink throughput capability of up to 543.46 Gbps from a single CPU. Test results can be seen in Figure 3.

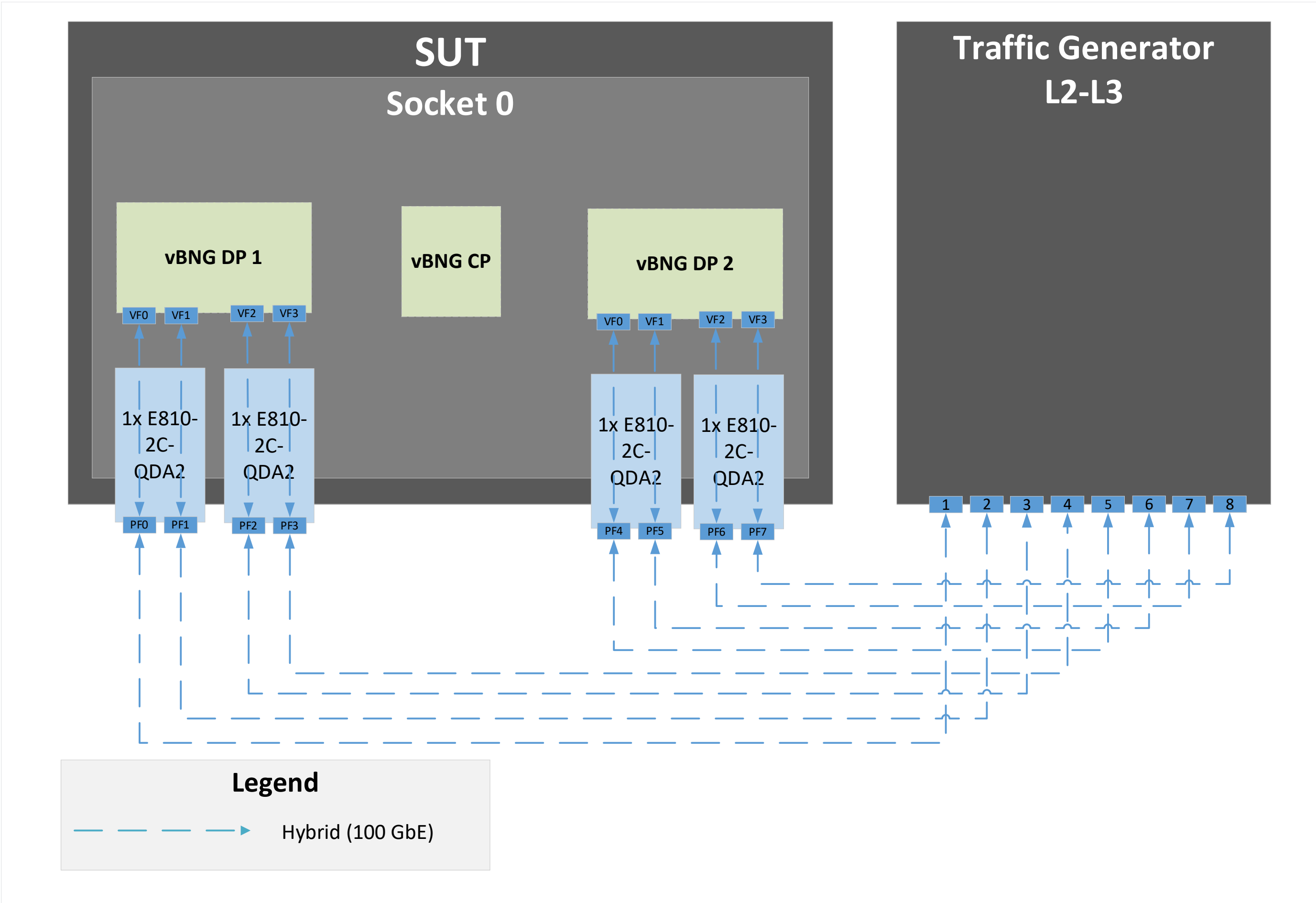


Figure 2. Network topology overview.

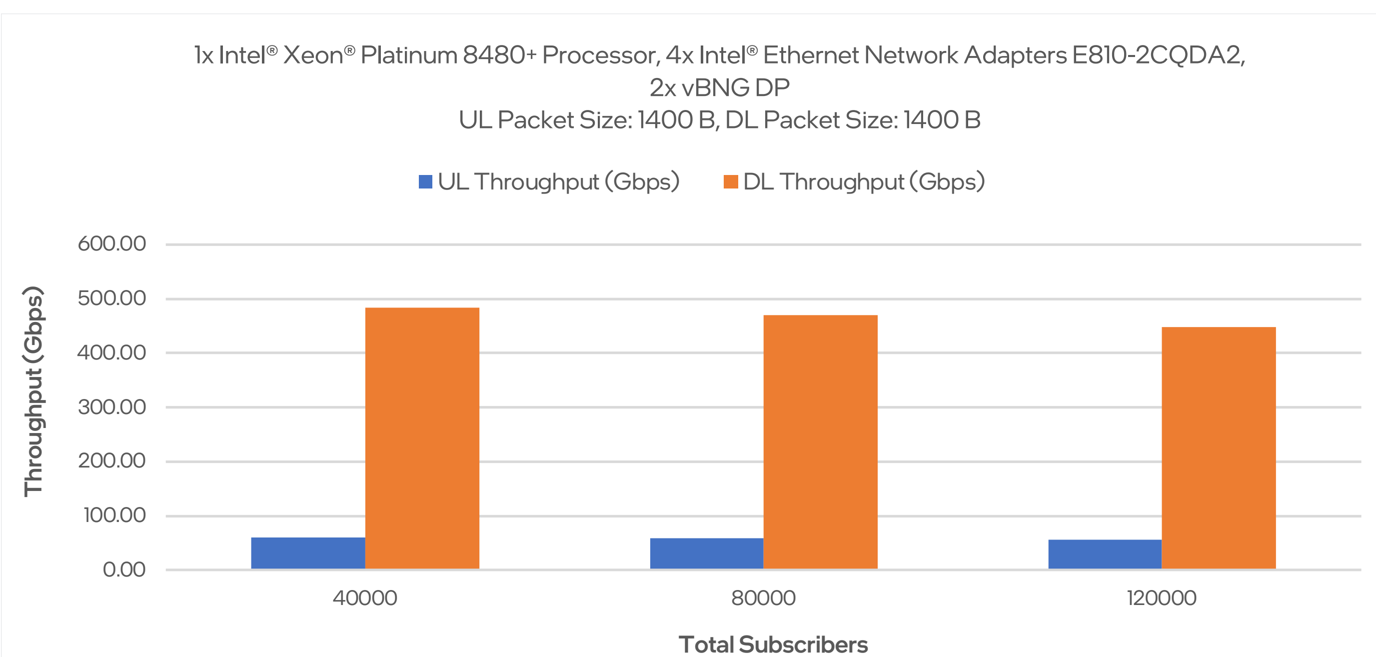
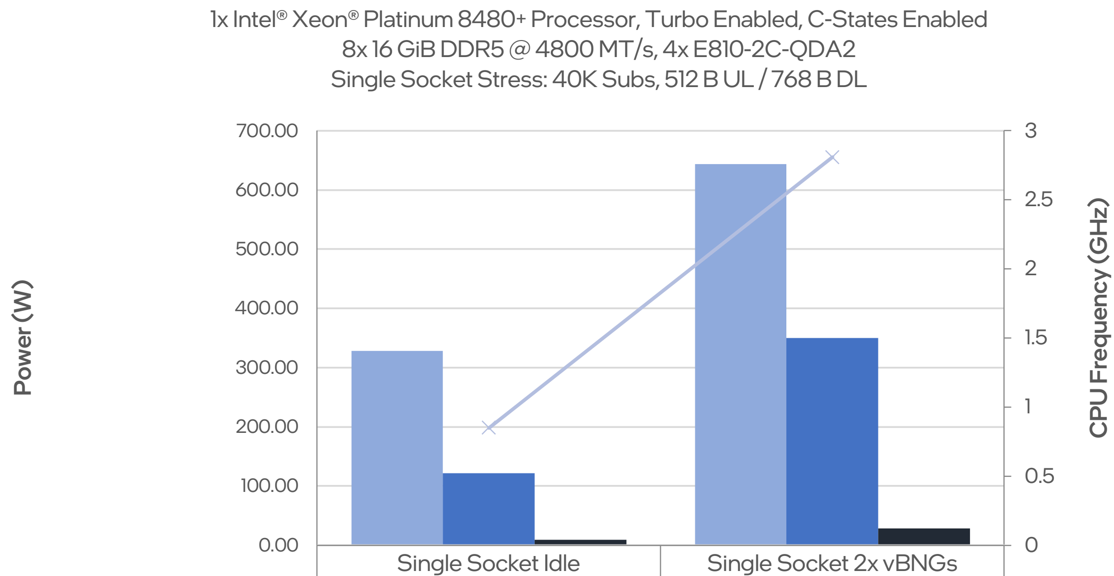


Figure 3. Uplink and downlink vBNG performance tested by Intel on 12/19/2022 (higher is better).



	Single Socket Idle	Single Socket 2x vBNGs
Total Wall Power (W)	328.00	644
CPU Power (W)	122.00	350
DRAM Power (W)	9.00	28
CPU Frequency (GHz)	0.849	2.809

Figure 4. CPU, DRAM, and server power consumption for a single socket topology tested by Intel on 12/19/2022 (higher is better).

While the performance improvement is very significant, the power savings is also just as important to communications service providers as they look to reduce their energy footprint. The results show power consumption scaling from approximately 328 Watts to 644 Watts for a single socket server where the vBNG is processing to its maximum capability (Figure 4). This provides an excellent opportunity for the network operators. As traffic varies in a broadband network, the network manager can realize significant energy savings by scaling compute capacity up or down based on predictable traffic models.

Conclusion

This solution brief demonstrates the performance of the Casa Axyom™ vBNG on 4th Gen Intel Xeon Scalable Processors along with Intel 800 Series Ethernet Controllers. In this case, the Casa Axyom™ vBNG is capable of generating up to 540 Gbps of throughput from a single NUMA node at less than 0.001% packet loss within a single server platform (Figure 3). Assuming linear scaling, this would extrapolate to 1 Tbps of throughput from a dual socket server with 4th Gen Intel Xeon Scalable Processors.

Specifically, the server platform leverages x16 PCI express Gen 4 I/O together with Intel 800 Series Ethernet Controllers, which supports two 2x 100 GbE connections within a single adapter. As a result, deploying the Casa vBNG workload on a server with 4th Gen Intel Xeon Scalable Processors and Intel Ethernet Network Adapters E810-2CQDA2 provides an improved base level of performance and power utilization, VNF consolidation within a single server capable of up to 800 GbE near the edge, all with significant potential for increased rack server density.

Learn More

4th Gen Intel® Xeon® Scalable Processors

100GbE Intel® Ethernet Network Adapter E810

Casa Systems Axyom vBNG

1.1 Hardware and Software BOM

The table below details the hardware BOM for the SUT.

COMPONENT	SPECIFICATION
Platform	Modular Single-Socket Reference Design for 4th Gen Intel® Xeon® Scalable Processor
Central Processing Unit (CPU)	1x Intel® Xeon® Platinum 8480+ CPU 112c 2.0 GHz 350W
Memory	8x 16 GiB (256 GiB) DDR5 4800 MT/s
Network Interface Card	4x 100 GbE Intel® Ethernet E800 Series E810-2C-QDA2
LAN On Motherboard (LOM)	1x Intel Corporation I210 Gigabit Network Connection (rev 03)
OS Drive	1x Samsung 240 GB MZ7LM240HCGR-000
Storage Drive	1x Intel 1 TB SSDPELKX010T8
BIOS	a2101f
Microcode	0x2b000041

Table 1. Hardware bill of materials. Tested by Intel on 12/19/2022.

https://builders.intel.com/docs/networkbuilders/intel-select-solutions-for-nfvi-v3-with-red-hat-openstack-platform.pdf presents the software stacks for Red Hat Enterprise Linux* (RHEL*), which is based on Intel® Select Solution for Network Function Virtualization Infrastructure (NFVI) on Red Hat* Enterprise Linux* and Red Hat* OpenStack* Platform Reference Architecture, Document number 606324.

With reference to https://builders.intel.com/docs/networkbuilders/intel-select-solutions-for-nfvi-v3-with-canonical-ubuntu.pdf, note that the SUT may also be deployed on Intel® Select Solution for Network Function Virtualization Infrastructure(NFVI) on Canonical Ubuntu* v3 Reference Architecture, document number 606325.

SOFTWARE STACK	RHEL8.6
Host OS	Ubuntu-Server 22.04.1 2022.09.21 (Cubic 2022-09-21 16:19)
Libvirt	8.0.0
QEMU	6.2.0
NVMe	1.0
vBNG DP Version	3.3.1
vBNG CP Version	3.3.1
DPDK	21.11
Ice	1.10.1.2

Table 2. Software stack configuration for system under test. Tested by Intel on 12/19/2022.

1.2 vBNG Test Workload Topology (Test Configuration)

The following table presents the resource allocation for the vBNG CP VM.

COMPONENT	SPECIFICATION
vCPUs	2C4T
Memory	10 GiB
Storage	12 GiB
MGMT Interface	1
DP Interface	N/A

Table 3. Resource allocation per vBNG CP VM. Tested by Intel on 12/19/2022.

The following table presents the resource allocation for each of the vBNG DP VMs.

COMPONENT	SPECIFICATION
vCPUs	24C48T
Memory	50 GiB
Storage	11 GiB
MGMT Interface	1
DP Interfaces	4x 100 GbE VFs (1x VF per PF)

Table 4. Resource allocation per vBNG DP VM. Tested by Intel on 12/19/2022.

The following table presents the traffic profile configured on the traffic generator as part of the benchmark. In this case, the traffic profile consists of a range of subscribers, from a total of 40,000 subscribers up to 120,000 subscribers. Note that all ports are configured in hybrid mode, in which case each virtual function may receive and process both access and core network traffic.

COMPONENT	SPECIFICATION
Total Access Network Subscriber Count	{40,000, 80,000, 120,000}
Core Network Endpoint Count	254
Access Network Packet Type	Q-in-Q encapsulated DHCPv4/IPv4 IPoE
Core Network Packet Type	VLAN encapsulated IPv4
MGMT Interface	1
DP Port Configuration	Hybrid mode (access & core)
Number of Network Topologies	8x 100 GbE networks
Number of Ports per Network Topology	1
UL:DL Line Rate Ratio	1:8
UL/DL Traffic Mix	{1400 B/1400 B}

Table 5. Network topology configuration settings. Tested by Intel on 12/19/2022.

The following figure presents the vCPU mapping for the CP VM along with both of the vBNG DP VMs. Note that in this case hyper-threading (HT) is enabled on the platform, with vCPUs allocated to each of the vBNG DP VMs in HT sibling pairs. In addition, note that 4C8T are reserved for the hypervisor.

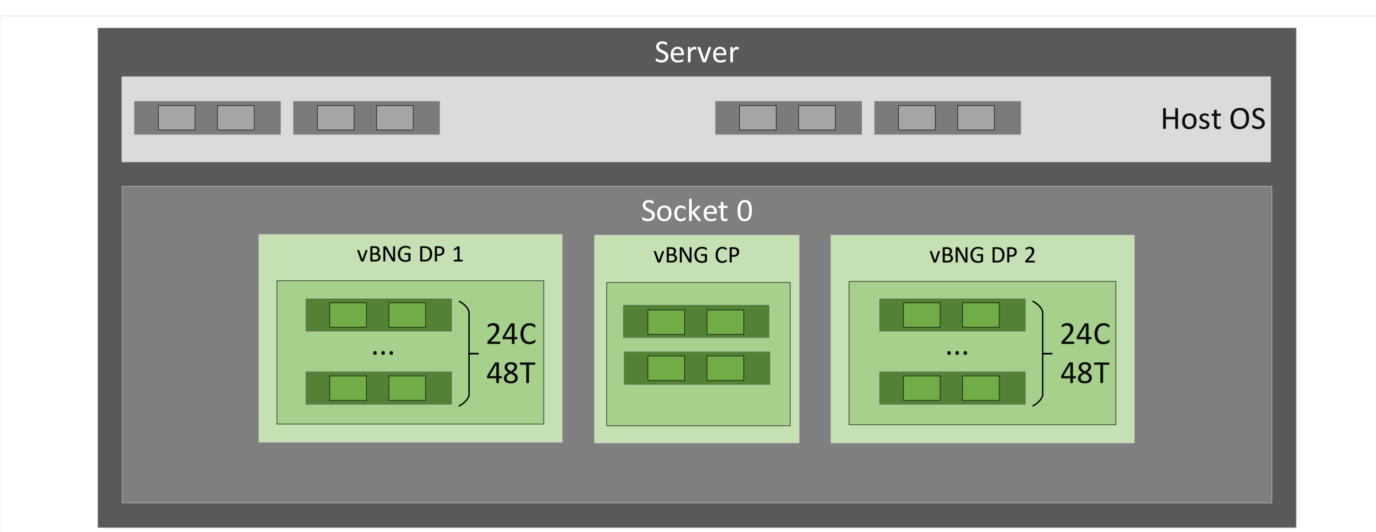


Figure 5. vBNG CP and DP vCPU mapping. Tested by Intel on 12/19/2022.

The following table presents the key performance indicators (KPIs) along with the boundary conditions for each of the corresponding KPIs where applicable.

KPI	UNITS / BOUNDARY CONDITION
Throughput	Gbps / RFC2544 at less than 0.5%
Packet Loss	% / Less than 0.5 %
Latency	μs / Less than 500 μs

[1] Testing was conducted by Intel on 12/19/2022 with servers and software described in sections 1.1 and 1.2 of this paper.

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