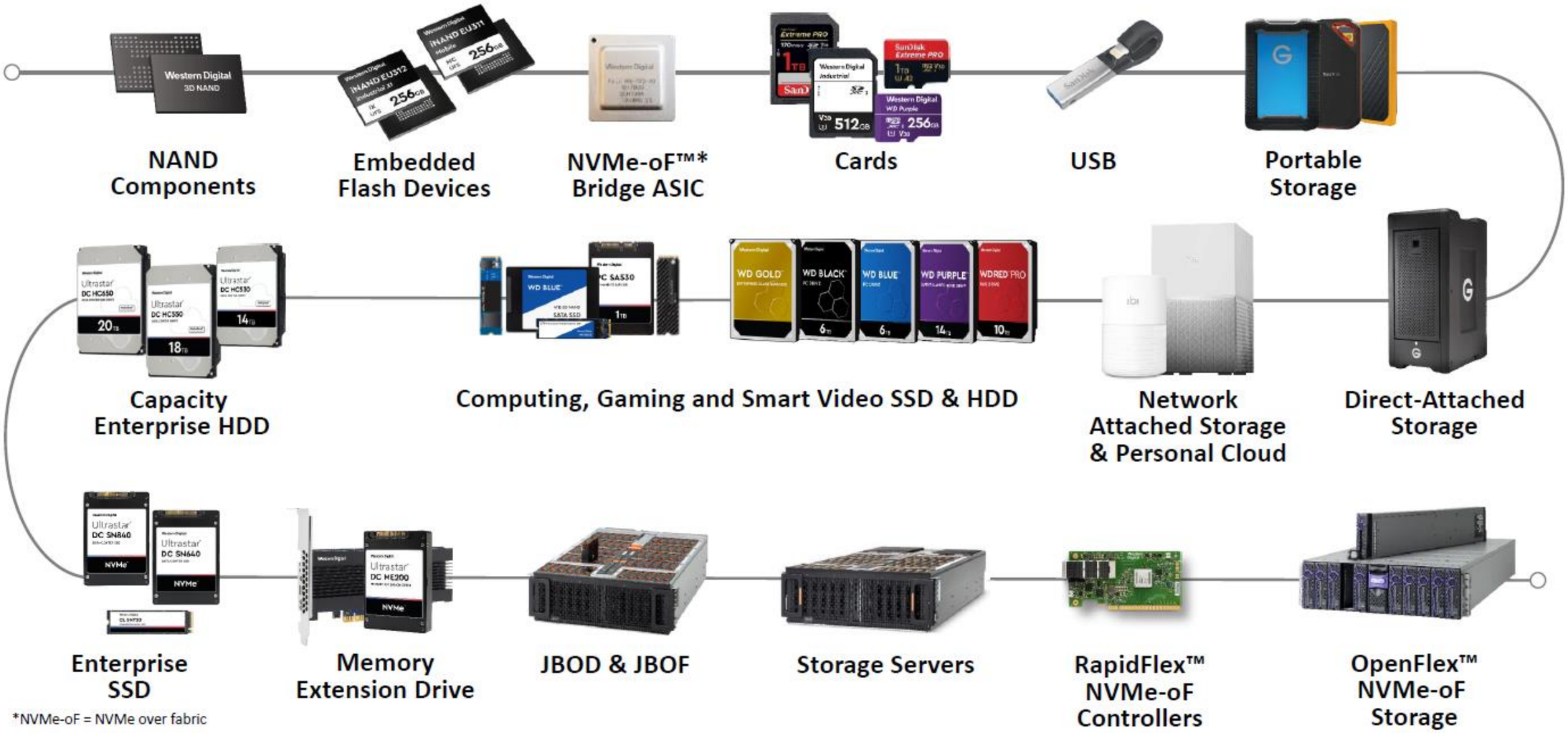
Leading Portfolio Breadth and Depth

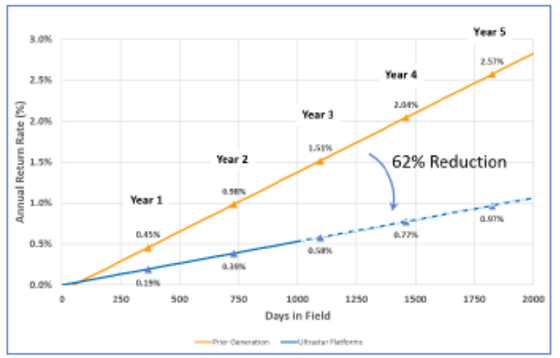
Solutions to capture, preserve, access and transform data

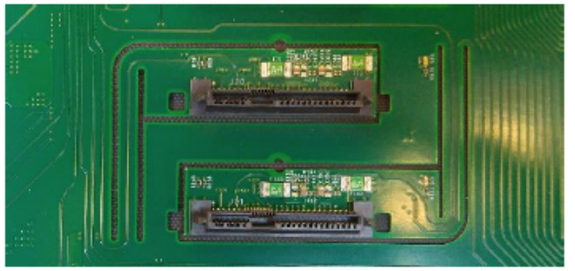


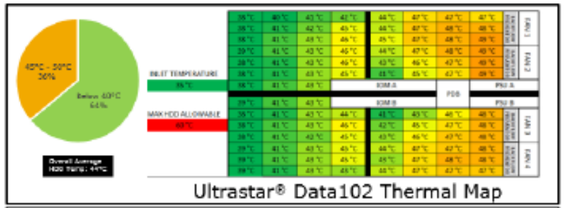
*NVMe-oF = NVMe over fabric

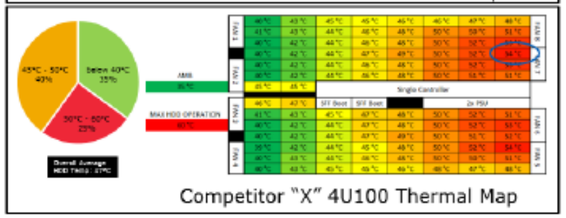
Ultrastar® Data Family Innovations

- Western Digital enclosures are different because we understand our devices and their interaction better than anyone
- Measured reduction of 62% in drive return rate*
  - Same HDDs, vs. previous generation JBOD without IsoVibe & ArcticFlow
- IsoVibe patented vibration isolation technology
  - Vibration Isolated HDD carrier/slot & fans
  - Over 60% lower vibration
  - Performance is maintained, even when all the drives are working hard
- ArcticFlow thermal zone cooling technology
  - Lower temperatures, improved reliability, energy savings
  - Projected 13% fewer drive failures
  - $1,500 in energy savings per enclosure
- Serviceability – maximizing “cold aisle” access
  - Rack mounted top cover
  - Top-load drives, tool-less carrier

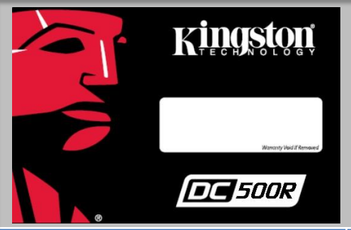




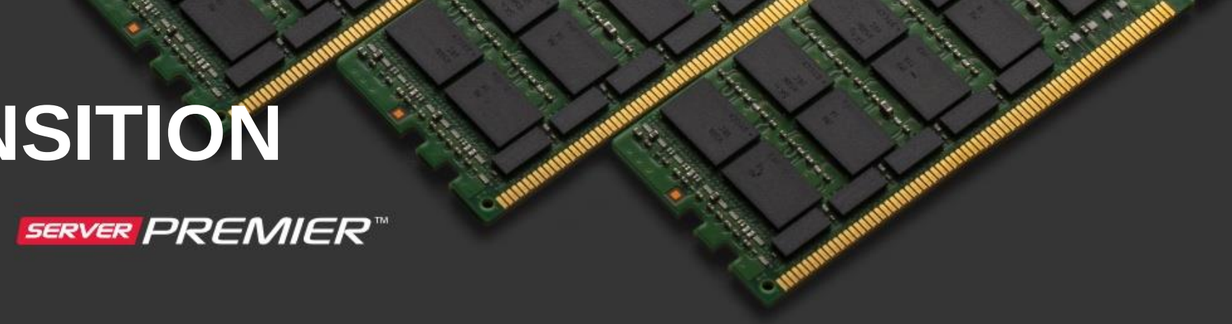

Ultrastar® Data102 Thermal Map


Competitor “X” 4U100 Thermal Map

* Based on observed drive return data, does not change product specifications and does not constitute a warranty

	SATA 2.5”	SATA 2.5”	SATA 2.5”	NVMe U.2	NVMe M.2
					
	DC500R (Read-Centric)	**DC500M (Mixed Use)**	**DC450R (Entry Level)**	**DC1000M (Mixed Use)**	**DC1000B (M.2 NVMe Boot)**
Status	Shipping	Shipping	Shipping	Shipping	Shipping
Capacities	480GB – 7.68TB	480GB – 3.84TB	480GB – 7.68TB	960GB – 7.68TB	240GB & 480GB (960G Q3’20)
128K Seq R/W *	555 MB/s 525 MB/s	555 MB/s 520 MB/s	560 MB/s 530 MB/s	3100 MB/s 2800 MB/s	3200 MB/s 565 MB/s
Form Factor	2.5” SATA III 6Gbps	2.5” SATA III 6Gbps	2.5” SATA III 6Gbps	U.2 NVMe	M.2 2280 NVMe
4K Random R/W *	98K/28K IOPS	98K/75K IOPS	98K/28K IOPS	540K/210K IOPS	205K/20K IOPS
Applications	Web Server, Streaming, Cloud, CDN	Database, OLTP, Cloud, Caching Tier	Web Server, Streaming, Cloud, CDN	Database, OLTP, CDN Cloud, Caching Tier	Server Boot
Features	.5 DWPD for 5 yrs Hardware PLP 256bit AES Encryption	1.3 DWPD for 5 yrs Hardware PLP 256bit AES Encryption	.3 DWPD for 5 yrs No Hardware PLP 256bit AES Encryption	1 DWPD for 5 yrs Hardware PLP	.5 DWPD for 5 yrs Hardware PLP 256bit AES Encryption
Warranty	5 Years	5 Years	5 Years	5 Years	5 Years

16Gb DRAM TRANSITION



SERVER PREMIER™

Beginning in Q4 2019, DRAM semiconductor suppliers began introducing the next generation high density DRAM for DDR4. Based on new wafer lithography (below 20nm), these new components double the storage density available, allowing higher capacity memory modules to be created.

Unfortunately, some legacy chipsets/processors from Intel have not been updated to support memory modules featuring these new chips. This will present a problem long-term for supporting customers with legacy platforms, as the DRAM suppliers begin to shift the majority of their DDR4 output to 16Gbit (Gigabit) density wafers.

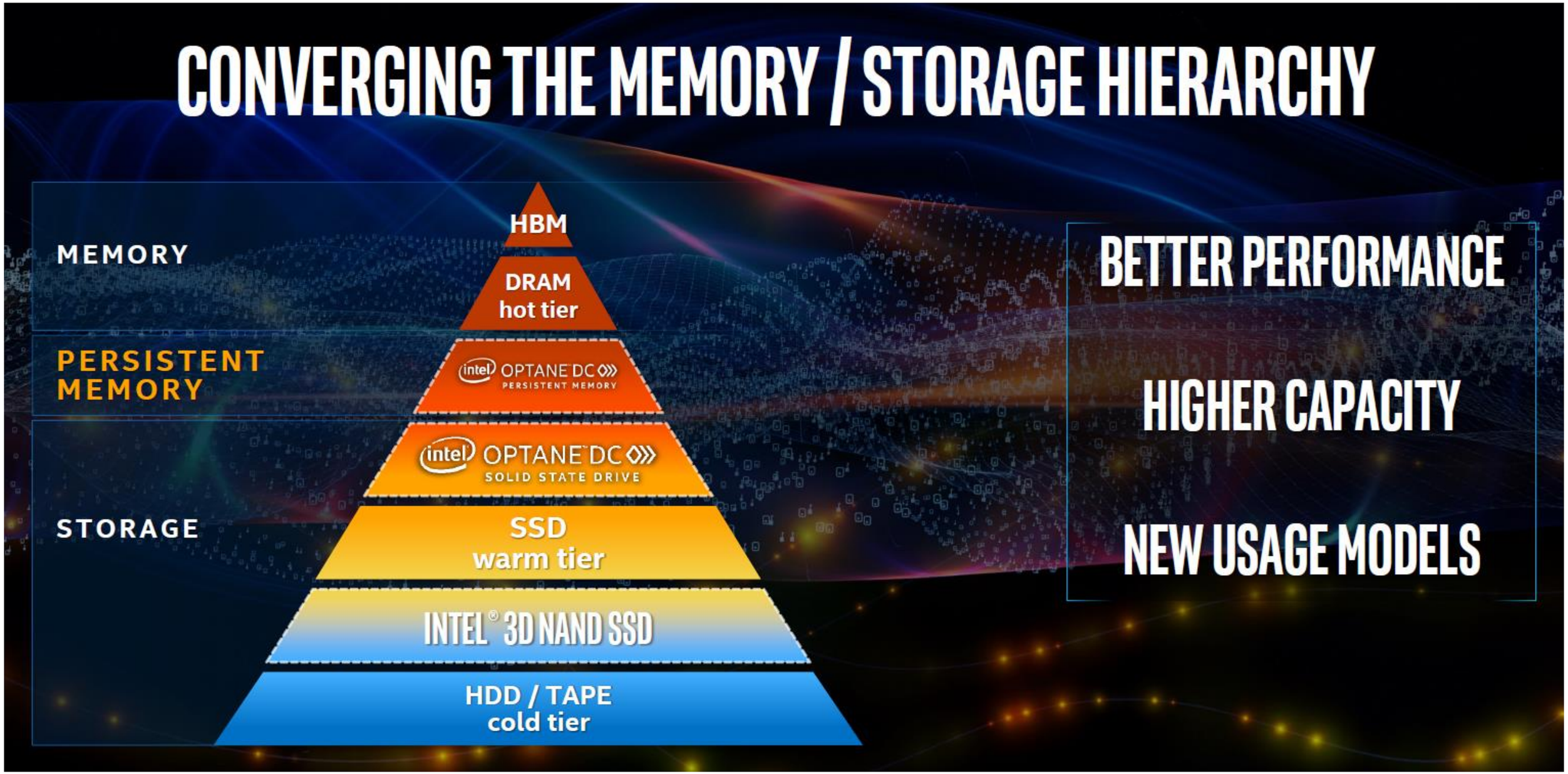
8Gbit	16Gbit
512Mb x16	1Gb x16
1Gb x8	2Gb x8
2Gb x4	4Gb x4

Module Types with 16Gb DRAM

8GB Unbuffered DIMM / SODIMM (1Rx16)
16GB Unbuffered DIMM / SODIMM (1Rx8)
32GB Unbuffered DIMM / SODIMM (2Rx8)
16GB ECC Unbuffered DIMM / SODIMM (1Rx8)
32GB ECC Unbuffered DIMM / SODIMM (2Rx8)
16GB ECC Registered DIMM (1Rx8)
32GB ECC Registered DIMM (2Rx8)
32GB ECC Registered DIMM (1Rx4)
64GB ECC Registered DIMM (2Rx4)

SERVER PREMIER

DDR4


CONVERGING THE MEMORY / STORAGE HIERARCHY
MEMORY
PERSISTENT MEMORY
STORAGE
HBM
DRAM hot tier
intel OPTANE DC PERSISTENT MEMORY
intel OPTANE DC SOLID STATE DRIVE
SSD warm tier
INTEL® 3D NAND SSD
HDD / TAPE cold tier
BETTER PERFORMANCE
HIGHER CAPACITY
NEW USAGE MODELS

NEW INTEL OPTANE PERSISTENT MEMORY 200 SERIES

Intel Optane Persistent Memory 200 Series

UP TO 40% BANDWIDTH * Improvement vs Intel Optane persistent memory 100 series

UP TO 3200 MT/S DDR4

15 WATTS Thermal Design Power

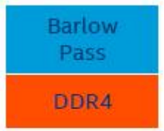
1H'20 PRQ — CEDAR ISLAND — 4 Socket Platform

6 CHANNELS Memory — **2666 MT/S** DDR4 — **3TB** Barlow Pass Per Socket

2H'20 PRQ — WHITLEY — 2 Socket Platform

8 CHANNELS Memory — **3200 MT/S[1]** DDR4 — **4TB** Barlow Pass Per Socket

Legend



HIGHER MEMORY FREQUENCY AND BANDWIDTH, IMPROVED APP PERFORMANCE, OPTIMIZED THERMALS

1.MT/S is Million Transfers / Second. For Cedar Island, 2933 2DPC & 3200 1DPC is POR. Stretch target is 3200 2DPC

*Many applications will benefit from higher memory frequency and bandwidth, those with bursty workloads can see an additional 20%-30% bandwidth increase using Intel Bandwidth boost, Applications whose OEMS implement eADR can see further application performance improvement

Intel® Ethernet Network Adapter E810-CQDA1/CQDA2

Efficient workload-optimized performance at Ethernet speeds of 1 to 100Gbps

Key Features

- Single and Dual-Port QSFP28
- PCI Express (PCIe) 4.0 x16
- Ethernet Port Configuration Tool (EPCT)
- Application Device Queues (ADQ)
- Dynamic Device Personalization (DDP)
- Supports both RDMA iWARP and RoCEv2

Improve application efficiency and network performance with innovative and versatile capabilities that optimize high-performance server workloads such as NFV, storage, HPC-AI and hybrid cloud.

Performance for Cloud Applications
Delivers the bandwidth and increased application throughput required for demanding cloud workloads including edge services, web servers, database applications, caching servers, and storage targets.

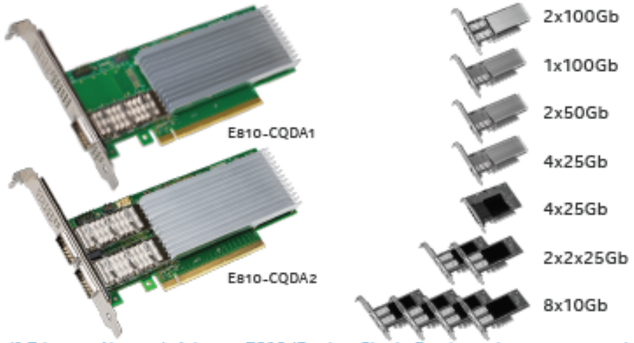
- Application Device Queues (ADQ) improves application response time predictability using advanced traffic-steering technology
- Dynamic Device Personalization (DDP) enhances packet classification capabilities, to deliver up to 3x throughput improvement[1] for some cloud workloads
- Supports both RDMA iWARP and RoCEv2 for high-speed, low-latency connectivity to storage targets

Optimizations for Communications Workloads
Provides packet classification and sorting optimizations for high-bandwidth network and communications workloads, including mobile core, 5G RAN, and network appliances.

- Dynamic Device Personalization (DDP) supports existing and new communications-specific protocols improving packet-processing efficiency up to 3x for some Network Functions Virtualization (NFV) workloads
- IEEE 1588 Precision Time Protocol (PTP) v2 enables precise clock synchronization across the 5G RAN deployments
- Enhanced Data Plane Development Kit (DPDK) support increases packet-processing speeds

Versatile Port Configurations with EPCT
E810-CQDA1 and -CQDA2 adapters support a wide range of system configurations to meet customer needs and workload requirements. The many port and speed combinations available simplify validation and deployment.

Connect to a wide range of switch speeds and media types



Using EPCT, the Intel® Ethernet Network Adapter E810 (Dual or Single Port), can be programmed to act as many different physical network adapters, with a maximum throughput of 100Gbps

Intel® Ethernet 800 Series Network Adapters are designed with Intel® Ethernet Controller E810 and include these features[2].

Host Interface
- Compliance with PCIe 4.0
- Concurrency for 256 non-posted requests

Software Interface
- Base mode VF compatibility with Intel® Adaptive Virtual Functions Specification
- Tx/Rx Queues
  - 2048 Tx queues and 2048 Rx queues
  - Dynamic allocation of queues to functions and VSIs
- Interrupts
  - 2048 interrupts vectors, allocated in a flexible manner to queues and other causes
  - Multiple interrupt moderation schemes
  - 20M interrupts/sec
- Control Queues (a.k.a. Admin Queues)
  - Mailbox Queues for PF-VF and driver-driver
  - Admin Queues for Software-Firmware control flows
  - Sideband Queues for Software to access IPs inside the E810
- 256 Tx Doorbell (DB) Queues
- 512 Tx Completion Queues
- Quanta Descriptor (QD) Queue per Tx queue. Quanta information is also embedded in the Tx doorbell
- Programmable Rx descriptor fields

Packet Processing
- Enhanced Data Plane Development Kit (DPDK)
- General
  - Stages of parsing, switching, ACLs, classification, packet modification
  - Programmable packet processing pipeline
  - Profile based
  - Programmable actions
  - Propagation of priorities between stages
- Parser
  - Parses up to 504B from packet header
  - Parse Graph based
  - Session-based parsing
  - Programmable parse engine
- Binary Classifier (VEB Switch)
  - 768 switch ports (VSIs)
  - Programmable forwarding rules
  - Storm Control
- ACLs
  - 8K programmable TCAM entries
  - Tiling capability to n*40b width
- Classification Filters
  - Hash-based statistical distribution
  - Intel® Ethernet Flow Director (Intel® Ethernet FD) flow-based classification
  - Flow-based identification of iWARP and RoCE flows
  - Programmable rules
- Modifier
  - Insert (Tx), remove (Rx), and modify of packet VLANs
  - L3 and L4 checksums and CRC

Virtualization
- Host virtualization via VMDQ and SR-IOV
- Up to 256 SR-IOV Virtual Functions
- Stateless offloads for tunneled packets (network virtualization support)
- Malicious VF protection
- Virtual machine load balancing (VMLB)
- Advanced packet filtering
- VLAN support with VLAN tag insertion, stripping and packet filtering for up to 4096 VLAN tags
- VxLAN, GENEVE, NVGRE, MPLS, VxLAN-GPE with Network Service Headers (NSH)
- Intel® Ethernet Adaptive Virtual Function drivers

RDMA
- iWARP and RoCEv2
- 256K Queue Pairs (QPs)
- Send Queue Push Mode

Note: RDMA is not supported when the E810 is configured for >4-port operation.

QoS
- WFQ Transmit scheduler with nine programmable layers
- Pipeline sharing and starvation avoidance
- QoS via 802.1p PCP or Differentiated Services Code Point (DSCP) value
- Packet shaping

Manageability
- SMBus operating at up to 1Mb/s
- DMTF-compliant NC-SI 1.1 interface at 100Mb/s
- MCTP over PCIe and SMBus
- Enterprise-level management schemes via local BMC
- SNMP and RMON statistic counters
- Watchdog timer
- PLDM over MCTP; PLDM Monitoring; PLDM firmware update; PLDM for RDE
- Firmware Management Protocol support

Power Management
- Supports PCI power management states D0, D3hot, D3cold

Time Synchronization
- Time stamp with each Rx packet
- Selective time stamps for Tx packets
- IEEE 1588 PTP v1 and v2 support
- Time synchronization signaling with other local platform ingredients

Pre-Boot
- Signed UEFI option ROM compatible with HTTPS boot

Security
- Hardware-based Root of Trust
- Authentication on NVM Read and Power On
- Built-in detection of firmware/critical setting corruption with automated device recovery