NVMe SSD Computational Storage

Seamless Programming, Compute Acceleration

Driving Compute and Storage Throughout the Datasphere!!

The Market Evolution and Need for Local Compute

Our Friends at Gartner Say it best…

Structured Data is great for current infrastructure

Allows for ease of data movement, location, access, compute

Only a small subset of the real data Iceberg

Unstructured Data is the greatest threat to results

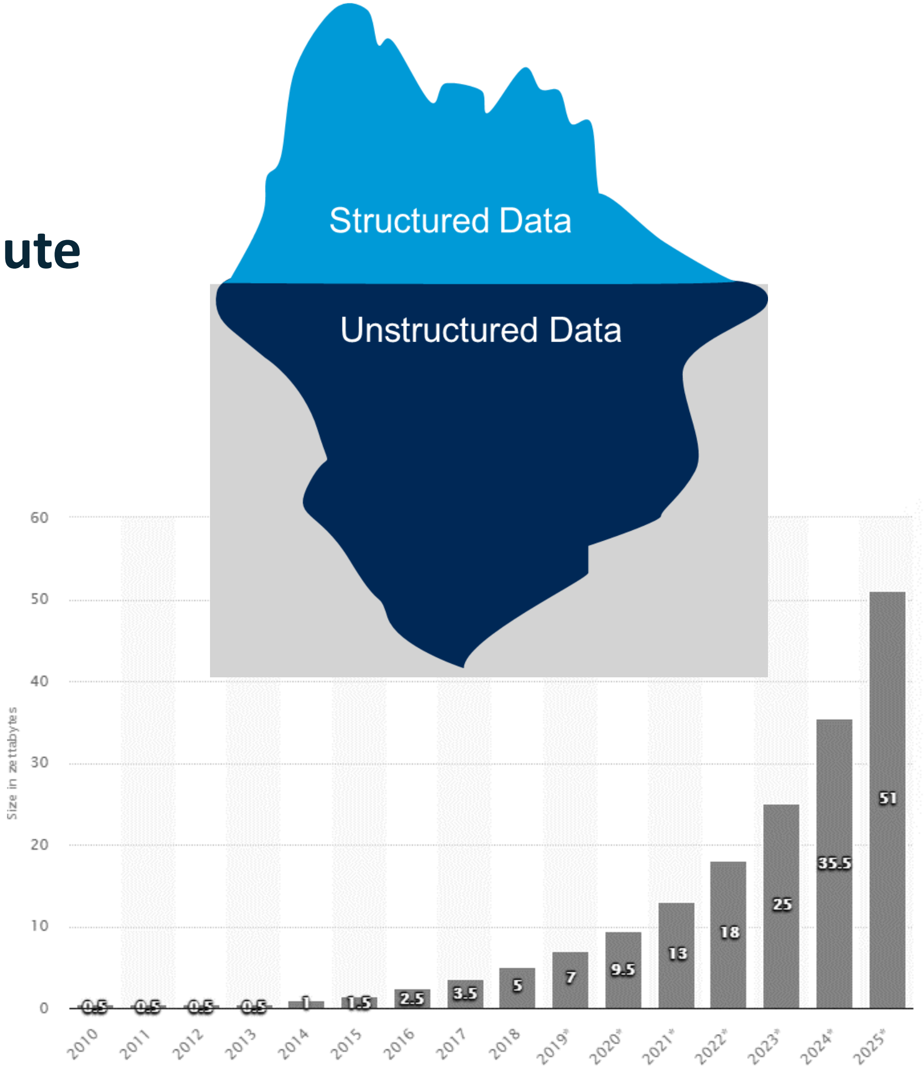
As more and more data is generated, it is more random

Needs to manage this data locally are key

Edge Computing is not able to scale at data growth pace

A new way to compute on random, local data is needed

The Global DataSphere (Statista.com) shows how the data growth is overshadowing the compute growth



The Market Needs a New Way to Look at Storage.

Pain Points

Physical Space

Available Power

Scaling Mismatch

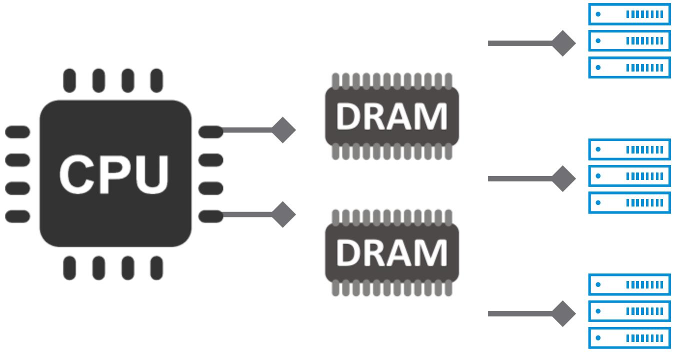
Bottleneck Shuffle

Traditional storage architectures are in **trouble**.

Scaling requirements are **not met** with existing solutions

One CPU to many storage devices **creates bottlenecks**

These bottlenecks exist, we currently just shift where they reside



Technologies that ‘**compose**’ these elements just move the bottleneck

A way to augment and support **without wholesale change** is needed

The Path to Compute Solutions is Paved with Smart Intentions

Finding paths to compute is easy… But one thing is very lacking in these ‘Smart Things’

Compute is Needed, DATA is Mandatory!

CPU – The Brain of the operations, starved for data, overwhelmed with requests

GPU – The Parallel processing Master, Nothing Persistent about it

NIC – The great Mover, not so great at processing

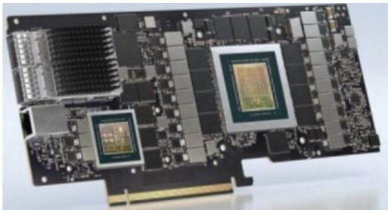
Smart NIC – The intelligent mover, but still doesn’t know what it is moving

DPU – The Processor closer to data, but still not persistent, still Volatile!

All these pieces are needed parts of the new ecosystem.

But NONE of them address the Real Issue…

The Data, where it is, where it comes from, and how to Store it!

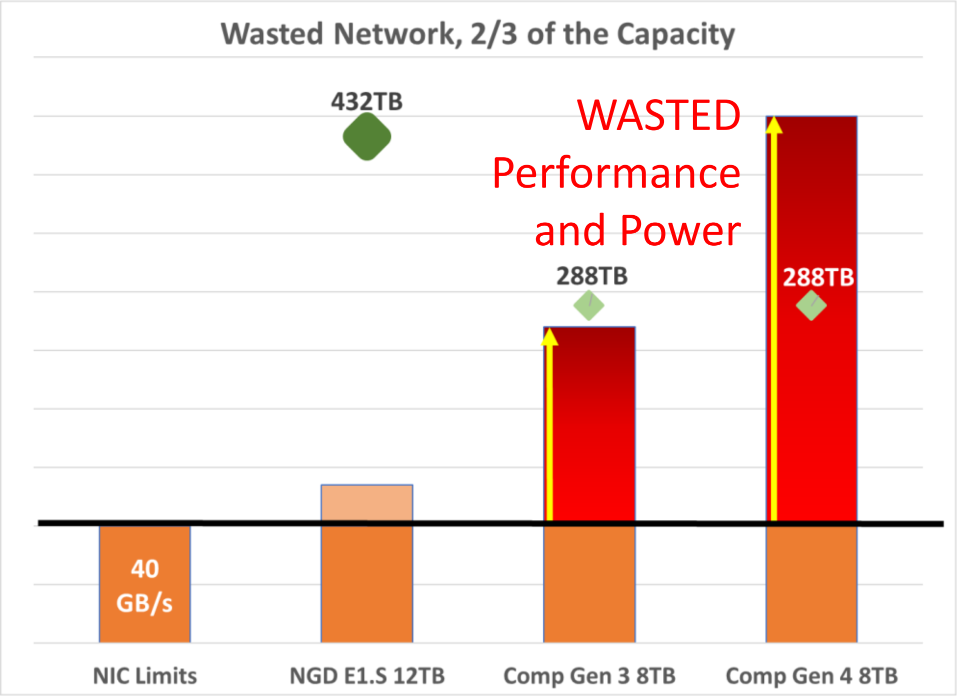


PCIe is Simply Not Enough.

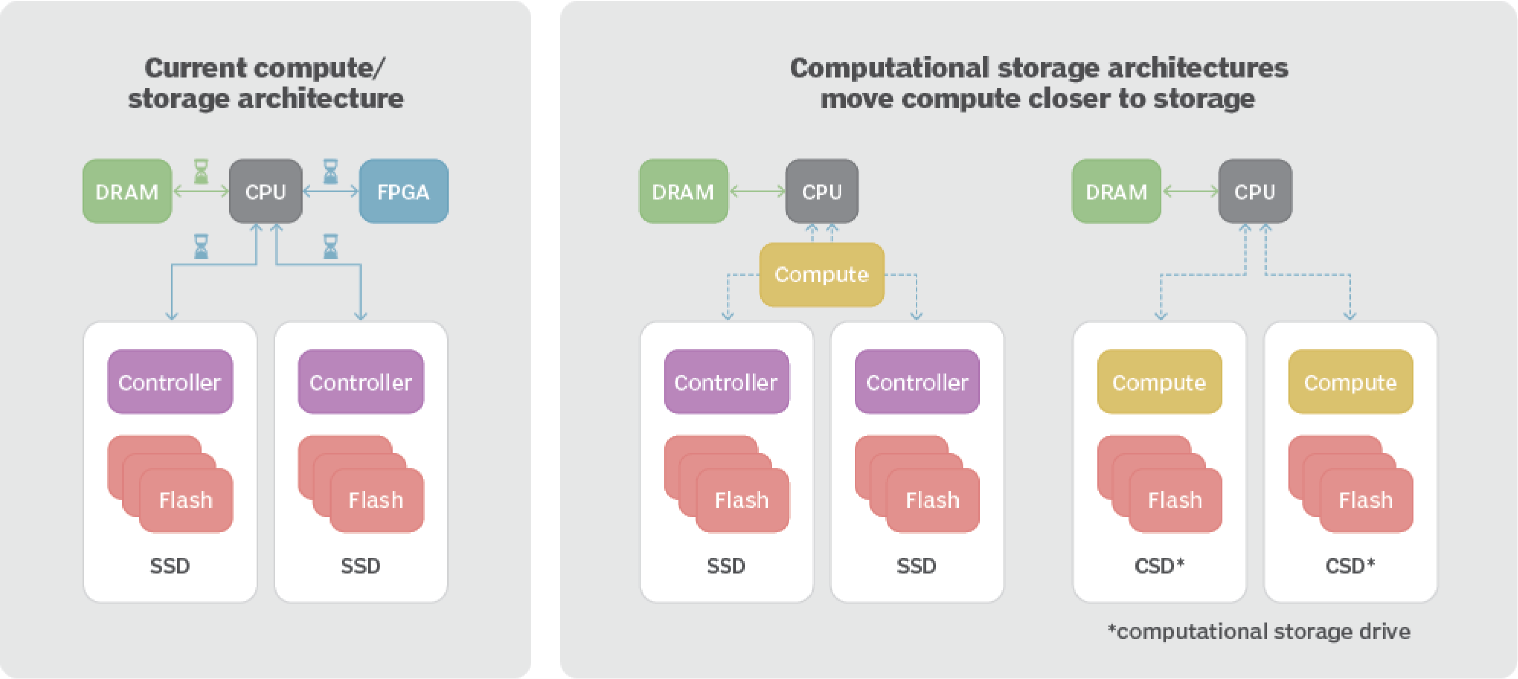
More Lanes, More Traffic, No Solutions

- **Storing** the Raw Data is easy!!
- **Working** on the Data will be Difficult
- **MOVING** the Data is Impossible
- **Solve** this with Computational Storage
  - Standardized, Open, Flexible

IDC predicts we will churn out <u>175 zettabytes</u> of data in 2025



The Value of Computational Storage – Core Count!



Computational Arm Cores

5376 Cores per 42U rack

16PB of Storage per rack

Value of Computational Cores

- ✓ Distributed Processing
- ✓ Near-Data Processing
- ✓ Smaller System Footprint

32 x E1.S hot swap NVMe SSDs
4 cores each
128 Additional Cores per 1U Server

NGD Systems High-Capacity, NVMe Computational Storage

What the Market is Doing to Drive Computational Storage

SNIA is driving for an Architectural Solutions

NVM Express is working on an Initial Instructions

Prototyping and Deploying Now

UNITED STATES SPACE FORCE
DEPARTMENT OF THE AIR FORCE
MMXIX

DELL EMC

IBM

Lenovo

Microsoft

SEAGATE

WD

Booking.com

Hewlett Packard Enterprise

arm

SNIA
Advancing storage & information technology

Computational Storage
Architecture and Programming
Model

Version 0.5 Revision 19

Abstract: This SNIA document defines recommended behavior for hardware and software that supports Computational Storage.

This Internal Use Draft is an internal document of the Computational Storage TWG that has not been approved for release outside of the membership of the Computational Storage TWG. This draft may not represent the position of the Computational Storage Technical Working Group.

Internal Draft

June 3rd 2021
For SNIA Computational Storage TWG Internal Use Only

nvm EXPRESS®

NVMe Computational Storage Task Group

The charter of Computational Storage Task Group is to develop features associated with the concept of **Computational Storage on NVM Express devices**.

The target audience consists of the vendors and customers of **NVMe Storage Devices** that support computational features.

SNIA CMSI | COMPUTE, MEMORY, AND STORAGE + SNIA | COMPUTATIONAL STORAGE

AMD · arm · BROADCOM · CALYPSO Systems · Codelucida · DELL EMC · EIDETICOM

EXTEN TECHNOLOGIES · FADU · FUJITSU · GIGAIO · Hewlett Packard Enterprise · HITACHI · IBM · INNOGRIT 英韧科技

inspur · intel · JETIO · KALRAY · KIOXIA · Lenovo · MARVELL · Micron

Microsemi a Microchip company · NEC · NetApp · NETINT · NGD systems · NVIDIA · NYRIAD

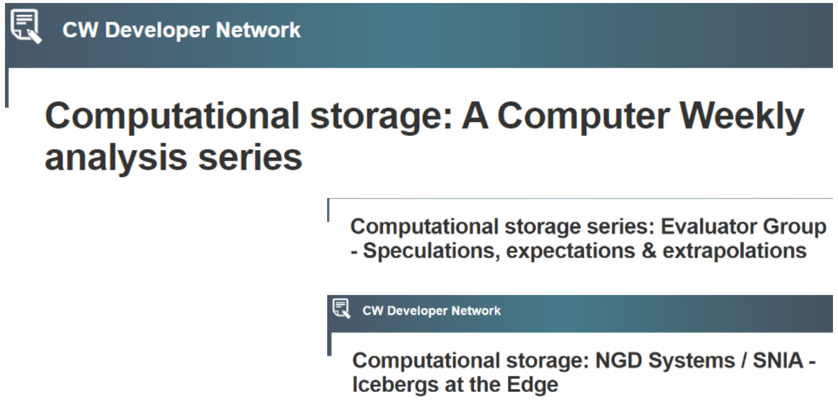
ORACLE · PLIOPS · ROCKPORT · SAMSUNG · ScaleFlux · SEAGATE · SiliconMotion

SK hynix · SMART Modular Technologies · SUPERMICRO · TOSHIBA · vmware · WD Western Digital · XILINX

Market Readiness for Computational Storage

NGD systems

- **Industry Investigations Grows**



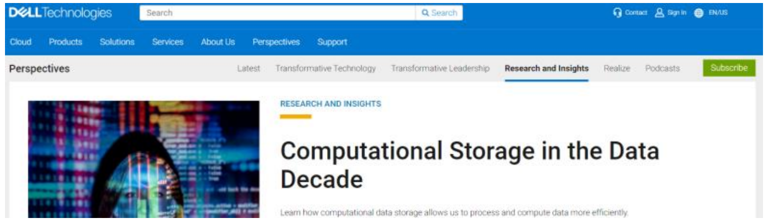
CW Developer Network

Computational storage: A Computer Weekly analysis series

Computational storage series: Evaluator Group - Speculations, expectations & extrapolations

CW Developer Network

Computational storage: NGD Systems / SNIA - Icebergs at the Edge

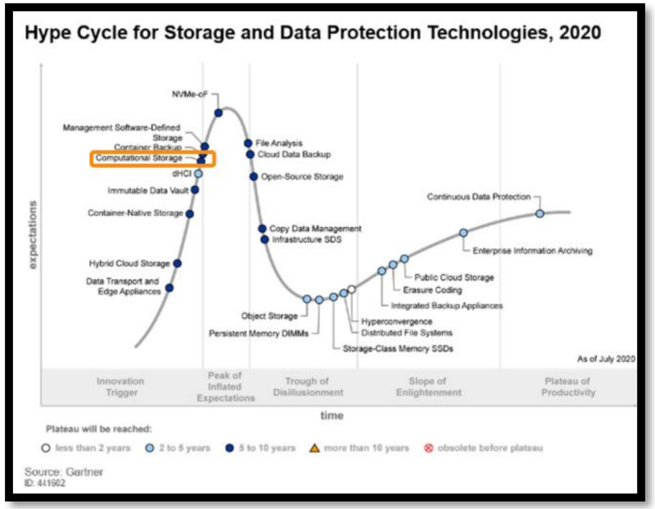


RESEARCH AND INSIGHTS

Computational Storage in the Data Decade

Learn how computational data storage allows us to process and compute data more efficiently.

- **Industry Analysts**
  - Gartner , IDC, Others



Hype Cycle for Storage and Data Protection Technologies, 2020

Source: Gartner
ID: 441602

- **Customer Sponsored Efforts**

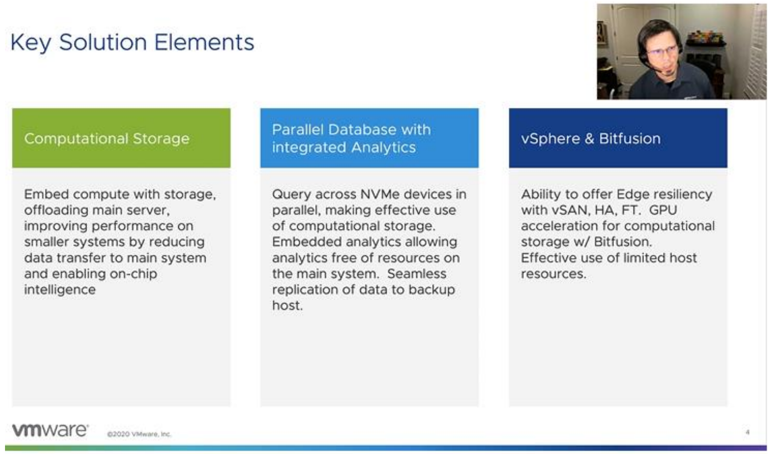
Los Alamos National Laboratory Welcomes NGD Systems to the Efficient Mission Centric Computing Consortium

Monday, August 2 2021

Los Alamos NATIONAL LABORATORY

EMC3

The collaborative effort will explore high capacity NVMe computational storage drive, and scalable computational offloads for HPC and scalable computing uses



Key Solution Elements

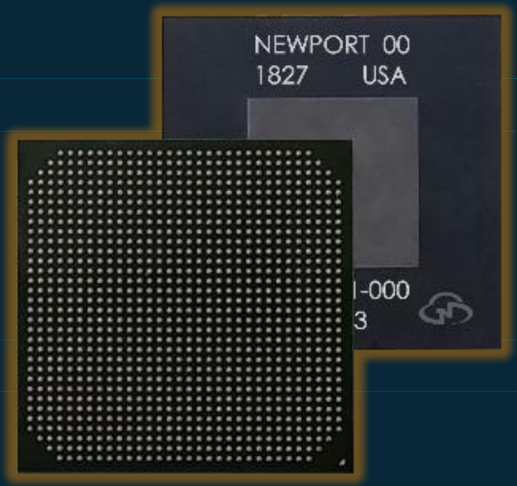
Computational Storage	Parallel Database with integrated Analytics	vSphere & Bitfusion
Embed compute with storage, offloading main server, improving performance on smaller systems by reducing data transfer to main system and enabling on-chip intelligence	Query across NVMe devices in parallel, making effective use of computational storage. Embedded analytics allowing analytics free of resources on the main system. Seamless replication of data to backup host.	Ability to offer Edge resiliency with vSAN, HA, FT. GPU acceleration for computational storage w/ Bitfusion. Effective use of limited host resources.

vmware ©2020 VMware, Inc.

How To Do It

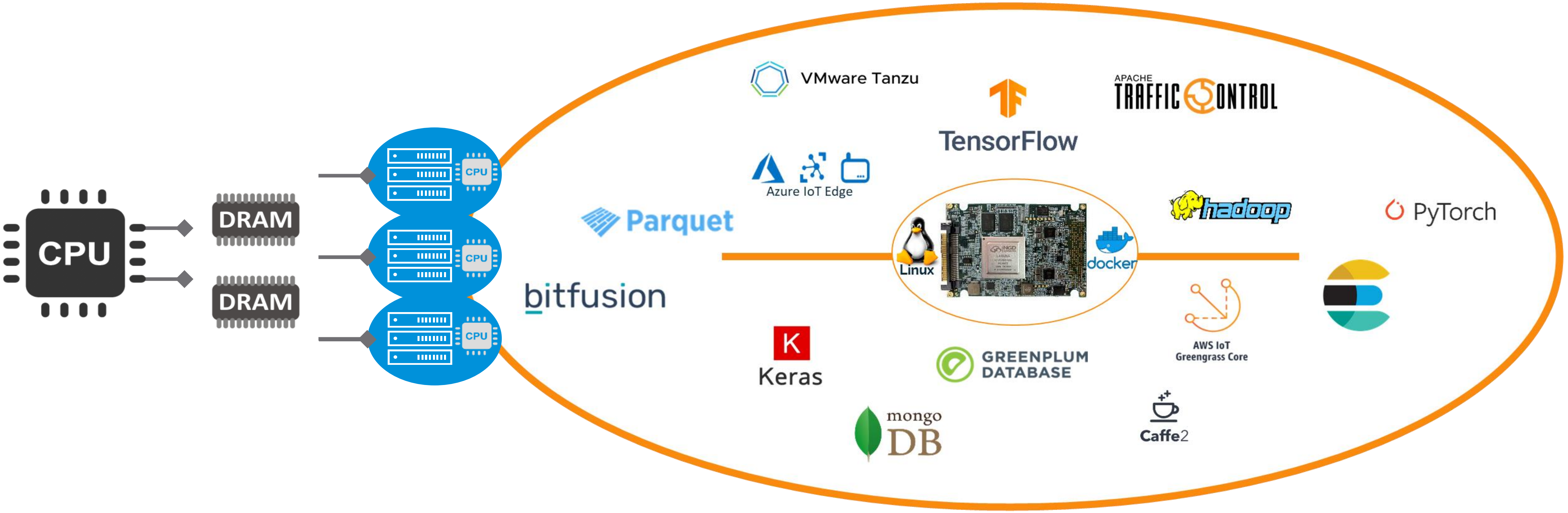
Keep It Simple and Seamless

ASIC-based, Single-chip, All in one Solution



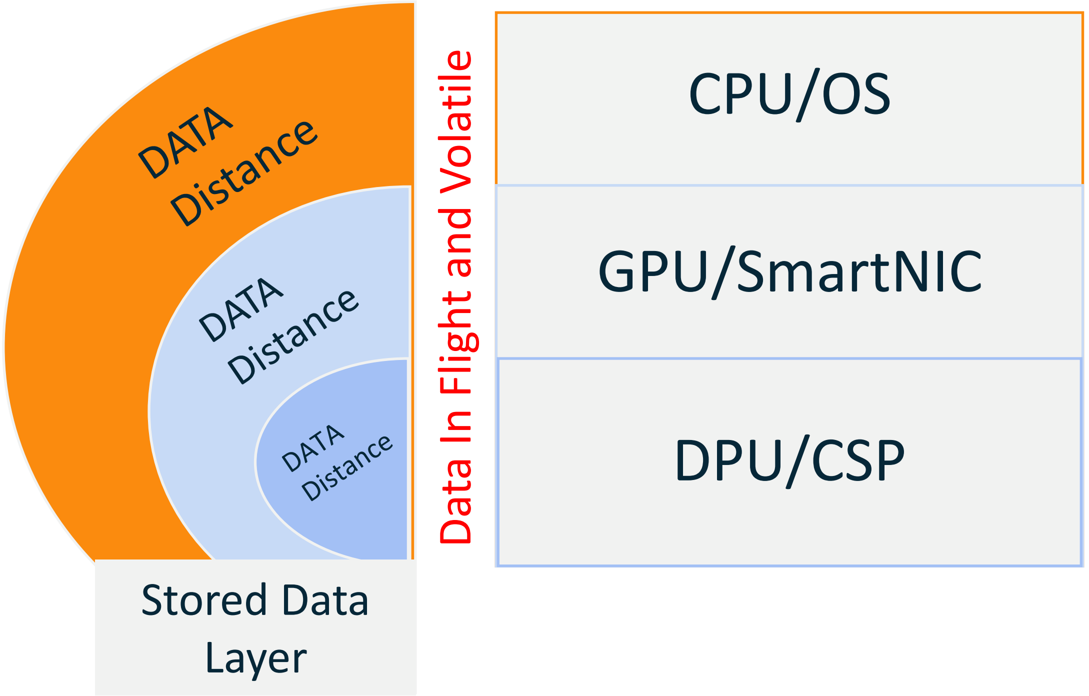
Some Examples of Linux Deployments with K.I.S.S.

- **Keep It Simple & Seamless**
  - The best way to move technology forward is to leverage architectures already in use

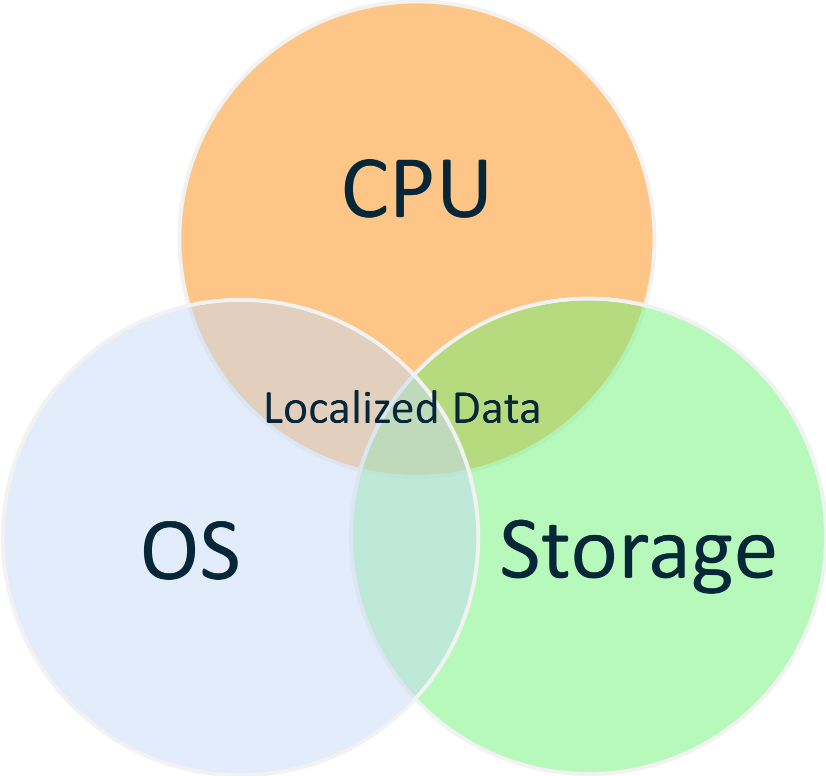


A Comparison of Compute Infrastructure – Why CSDs?

Today's Standard Infrastructure – **Data Distant**

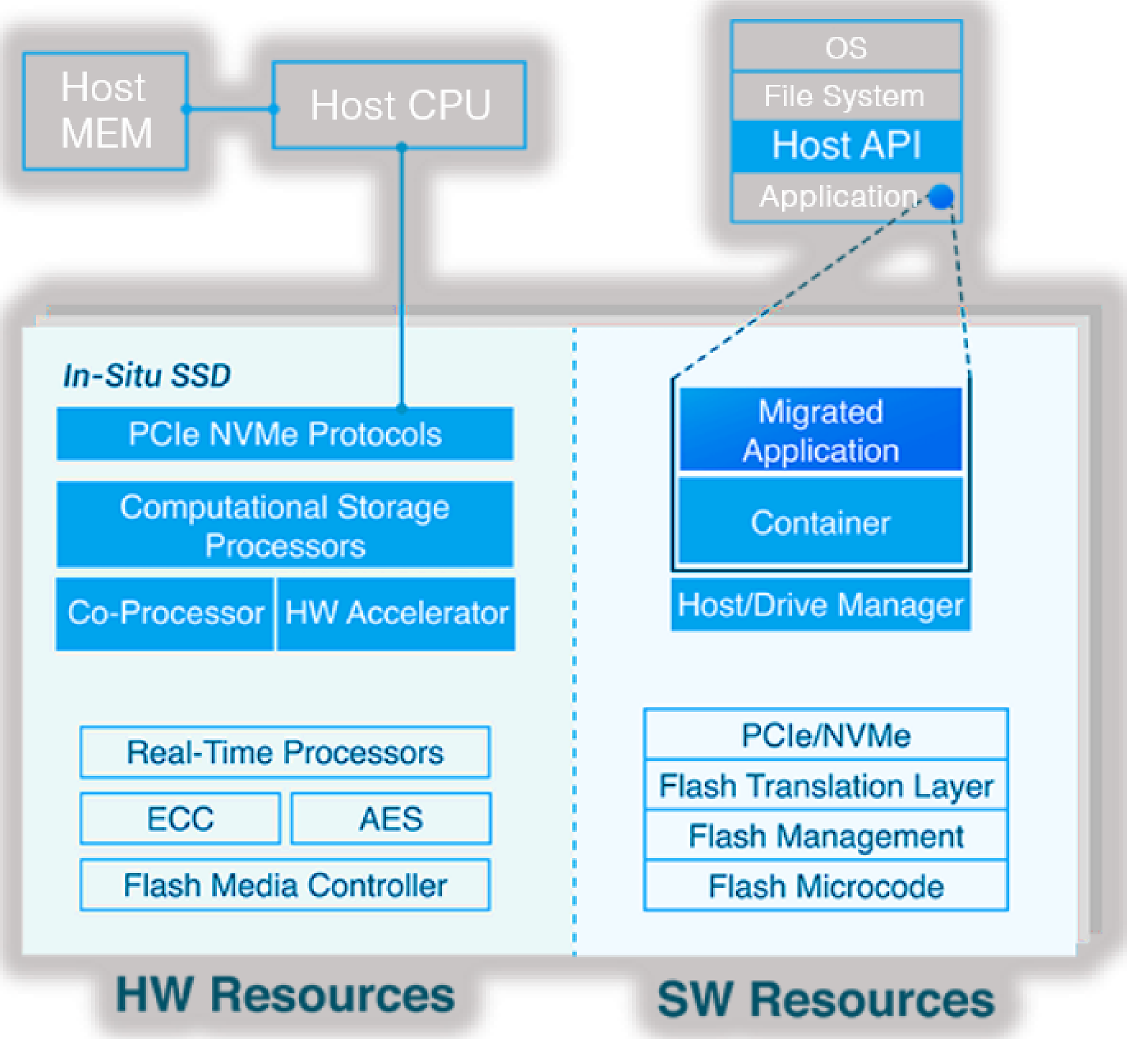


Linux-Based Computational Storage Drive – **Data Locality**



A Look at the Hardware and Software of a Linux-Based CSD

NGD systems



Host MEM

Host CPU

OS

File System

Host API

Application

In-Situ SSD

PCIe NVMe Protocols

Computational Storage Processors

Co-Processor | HW Accelerator

Real-Time Processors

ECC | AES

Flash Media Controller

Migrated Application

Container

Host/Drive Manager

PCIe/NVMe

Flash Translation Layer

Flash Management

Flash Microcode

HW Resources

SW Resources

Computational Storage Software

Sample Applications

elastic

PyTorch

vmware

Parquet

TensorFlow

mongoDB

APACHE TRAFFIC CONTROL

chia

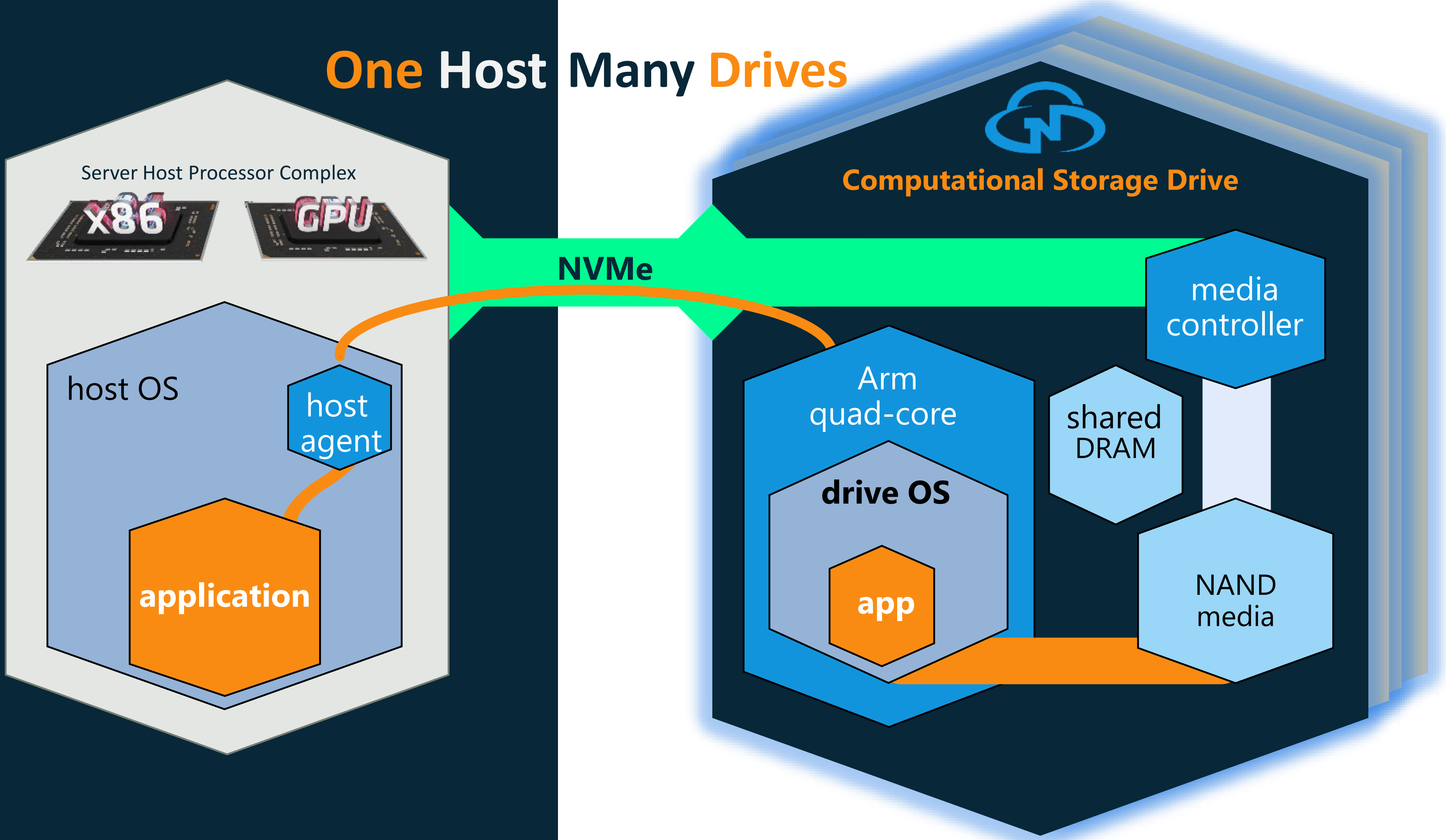
docker

kubernetes

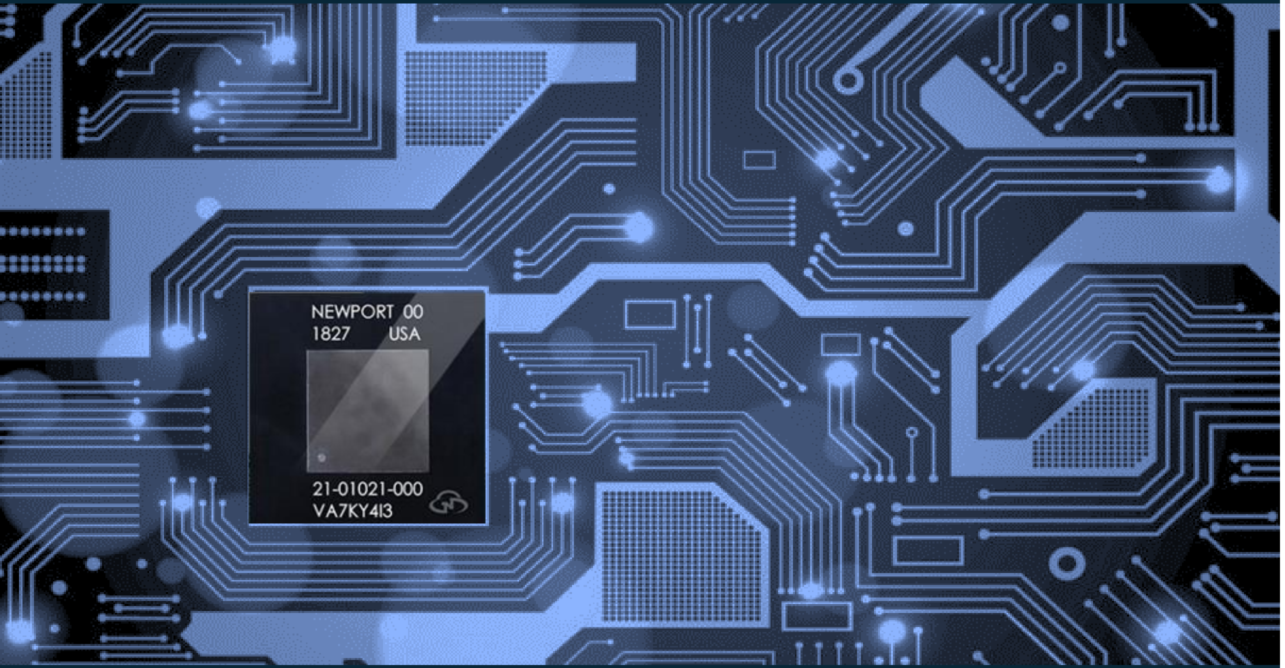
Containers

Microservices

The Data Lives on Storage. Why Not Work on it There?



Computational Storage, Some Real World Results.

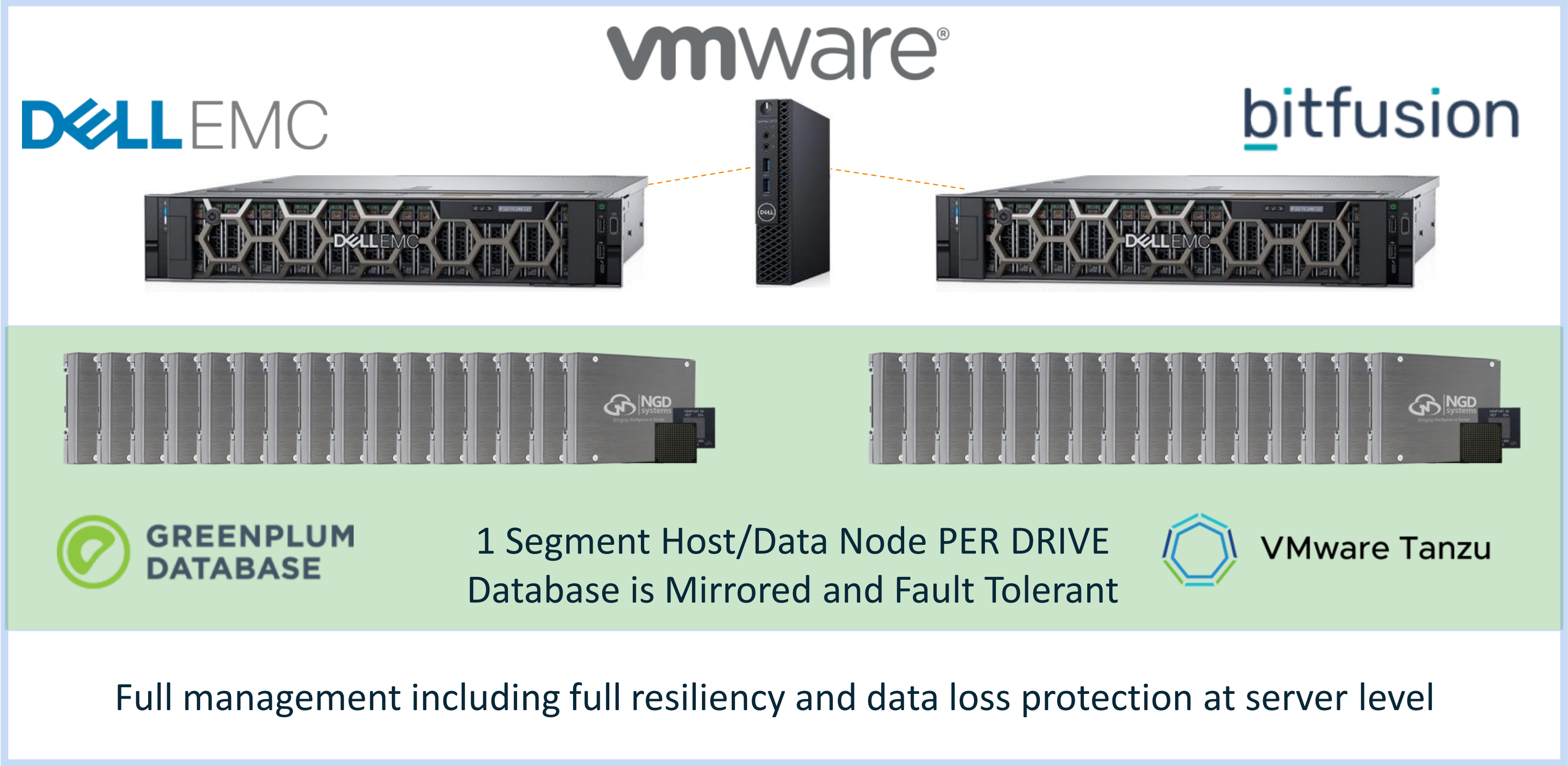


- Compression Acceleration – GZIP
- CDN-in-a-Box – Real Customer Lab Results
- AI Inference in the Datacenter – FAISS
- Inferencing at the Edge - WiSARD
- Distributed Machine Learning - Stannis
- Data Search – Elasticsearch
- Distribute Processing – Hadoop

Edge Analytics – Live Demo with VMware – xLab 52

Computational Storage allows it to be drive level.

Reducing footprint, server cost, while still offering full fault tolerance



1 Segment Host/Data Node PER DRIVE
Database is Mirrored and Fault Tolerant

Full management including full resiliency and data loss protection at server level

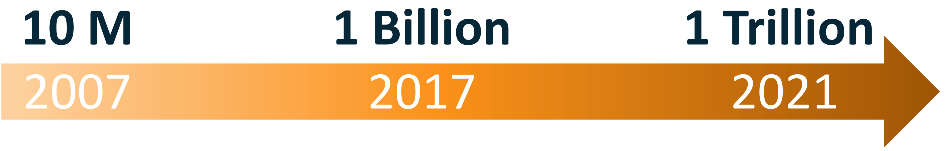
Showcased at Vmworld 2020 - Session ID [OCTO478] –

Computational Storage, Tanzu Greenplum, vSphere Bitfusion

Finding the Needles in Haystacks with AI and CSDs

Problem Statement

- Databases growing at exponential rates



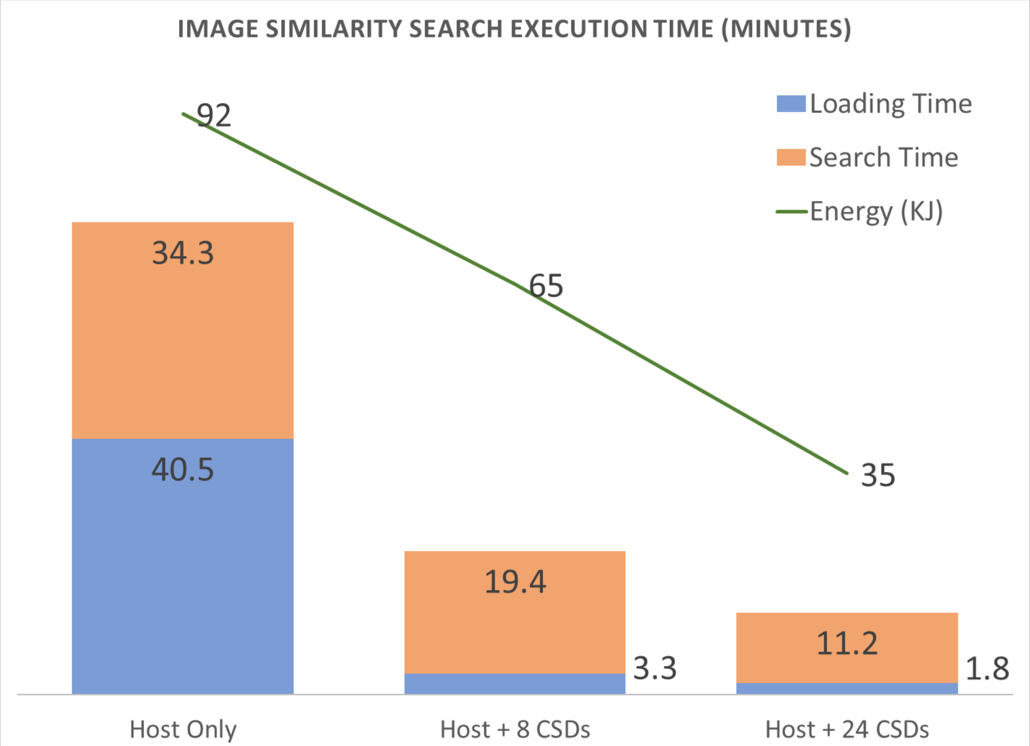
- Load and Search time key blocks in getting results

Computational Storage Solution

- Determine best way to increase performance
- Load Time Reductions due to CSD Offload of AI code

Results are Proven:

Load Time Reduced	> 95%
Search Time Reduced	> 60%
Power Savings of	> 60%



Association for Computing Machinery

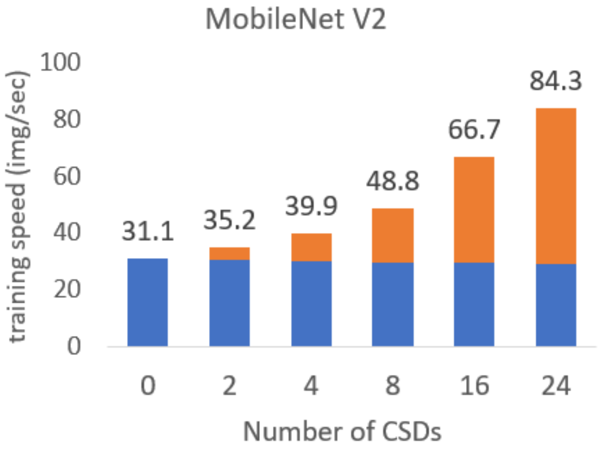
Microsoft

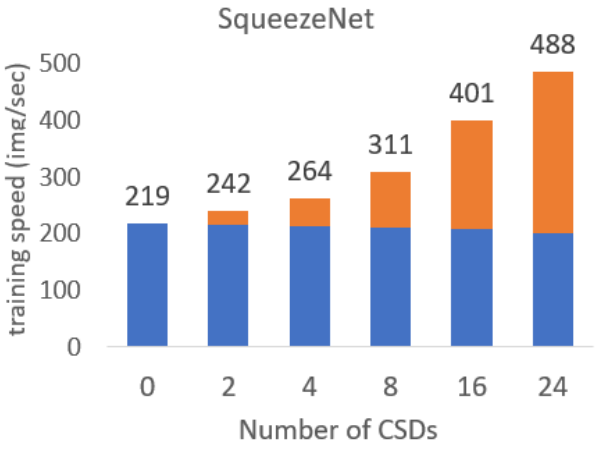
Technical paper published in the ACM journal on Computational Storage

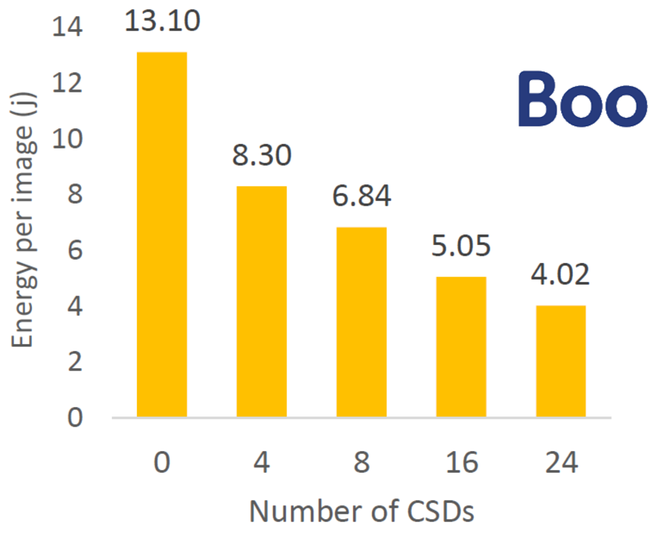
Machine Learning At Scale – Not Just One Way

NGD systems

- Four neural networks Evaluated
  - **MobilenetV2**
  - NASNet
  - **SqueezeNet**
  - InceptionV3Quad-core
- Tested with 24 CSDs
- Training data stored on CSDs
- Using an AIC 2U-FB201-LX server
  - Intel® Xeon® Silver 4108 CPU
  - 32GB DRAM



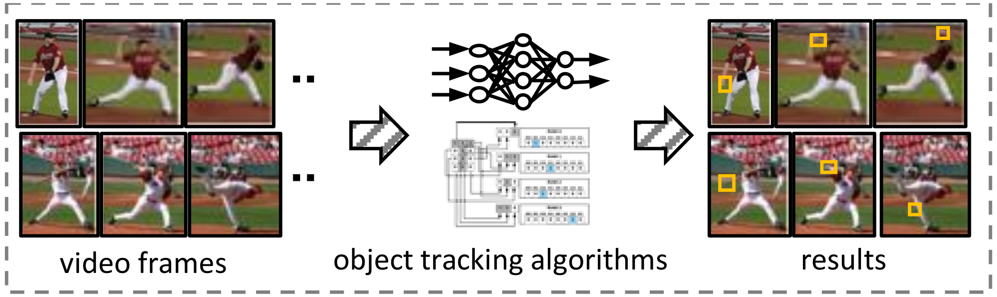


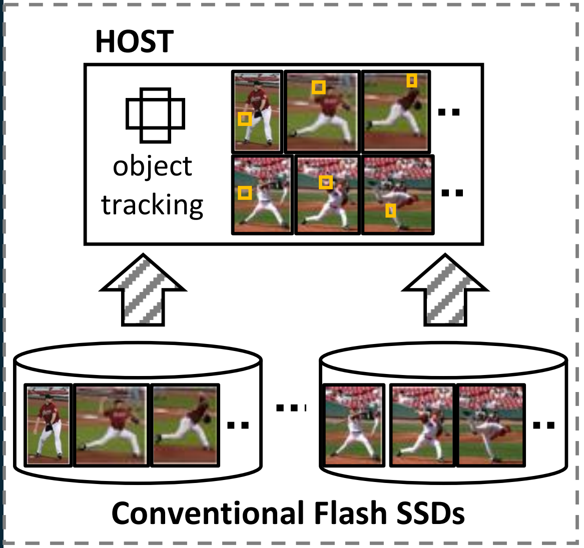


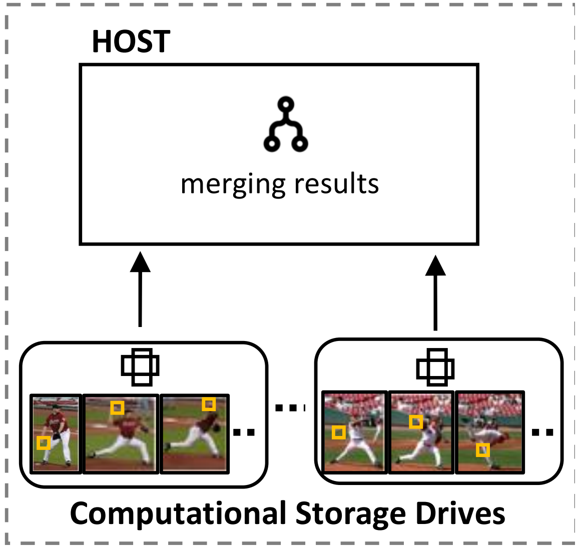
Booking.com

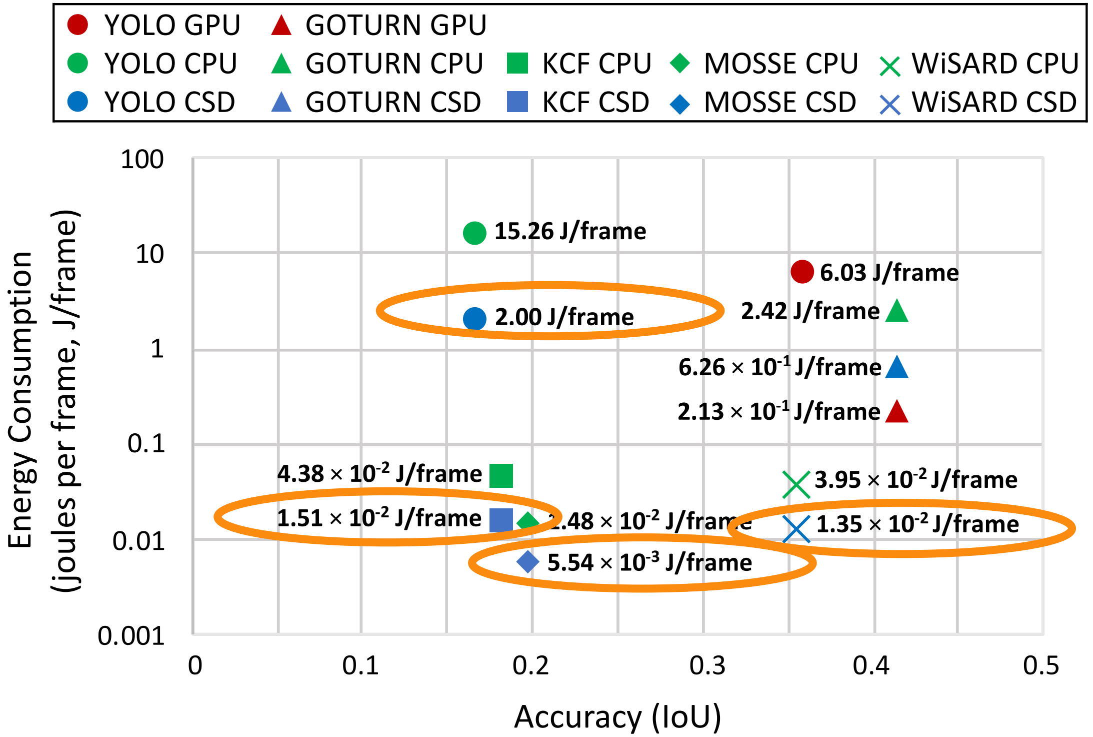
Computer Vision – Lower Power, Same Results.

- **Scalable solution**
- **Energy efficiency gains (~10x)**







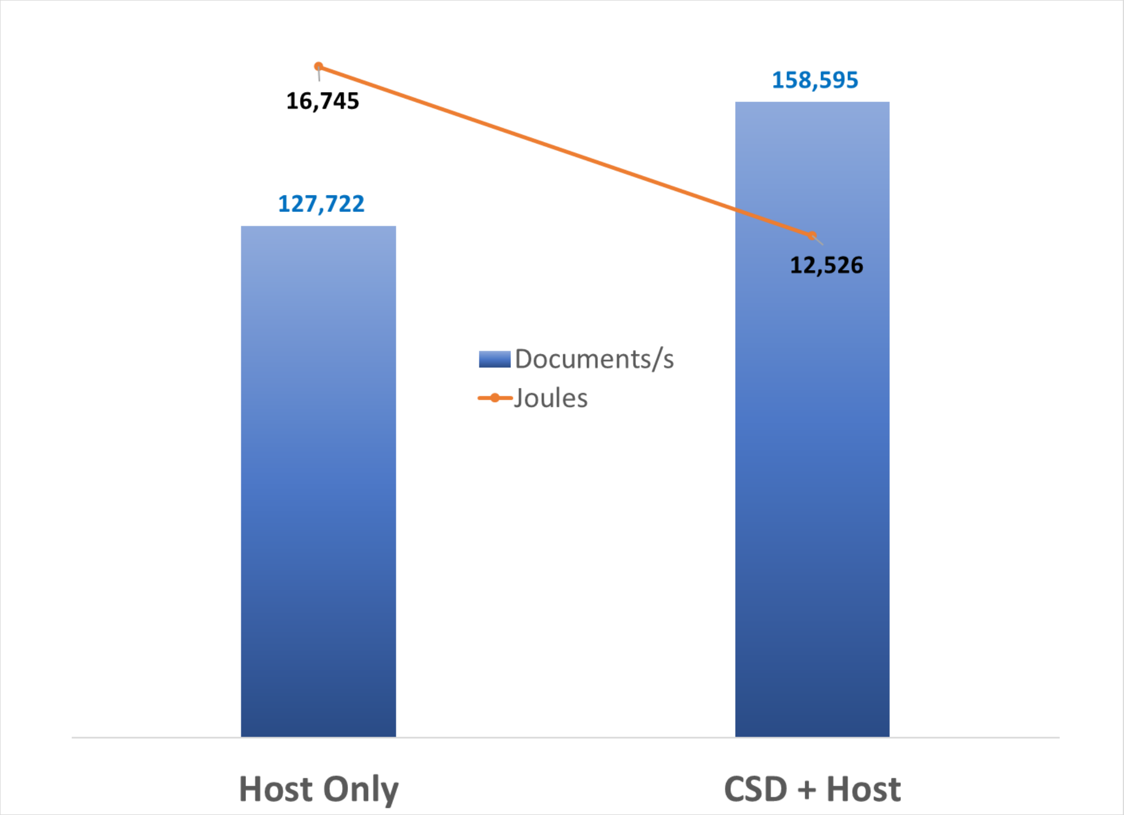


CSD Results Are equal in accuracy with Less Power

Hybrid Configuration Performance Results

- **Total Performance Improves**
  - **20% Better** Results
- **Reduced Power Consumption**
  - **30% LESS** Power
- **DRAM Usage Reduced by >50%**
  - Host Only used **25GB**
  - Hybrid used **12GB**
- **CPU Usage Utilization Reduced by >50%**
  - Host Only used **24%**
  - Hybrid used **10%**

elasticsearch



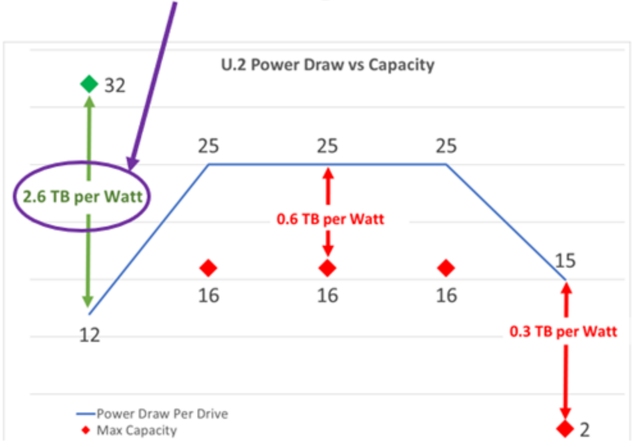
NGD NVMe CSD Products at a Glance.

- Large breadth of **SSD** solutions and capacity options
- Leading **TB/W** Energy Efficiency
- Only **16-Channel** 14nm SSD SoC & 100% Made in the USA
- Industry's Largest capacity NVMe SSDs
- Quad-Core **Computational Storage CPUs**

Form Factor	Availability	Raw Capacity TLC (TB)	MAX Power (W)
M.2 2280	CQ3'20	up to 4	8
M.2 22110	NOW	up to 8	8
U.2 15mm	NOW	up to 32	12
EDSFF E1.S	NOW	up to 12	12
EDSFF E3	Planned	up to 64	12

NGD is the ONLY Provider of Capacity over Power

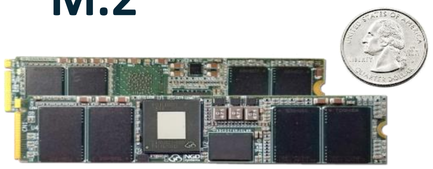
Another Paradigm Shift in the Market



NGD Competitors

U.2

M.2



E1.S

How Can We Help?